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In the two tables below, we have shown how the three variables affect the amount of decentration. In calculating the decentration for strong plus reading lenses, especially in cases of binocular aphakia, a bit too much decentration is preferable to too little decentration.

The tables show the amount of decentration, in mm., for *each* eye. The vertex distances and interpupillary distances are in millimeters and the reading distances are in inches.

Lenses 10 M/M from Eyes

Reading Distance	Interpupillary Distance 58	60	62	64	66	68	70
14"	1.7	1.8	1.9	1.9	2.0	2.0	2.1
15	1.6	1.7	1.7	1.8	1.8	1.9	2.0
16	1.5	1.6	1.6	1.7	1.7	1.8	1.8
17	1.4	1.5	1.5	1.6	1.6	1.7	1.7
18	1.4	1.4	1.5	1.5	1.6	1.6	1.6

Lenses 13 M/M from Eyes

Reading Distance	Interpupillary Distance 58	60	62	64	66	68	70
14"	2.0	2.0	2.1	2.2	2.2	2.3	2.4
15	1.8	1.9	2.0	2.0	2.1	2.2	2.2
16	1.7	1.8	1.8	1.9	2.0	2.0	2.1
17	1.6	1.7	1.7	1.8	1.9	1.9	2.0
18	1.5	1.6	1.6	1.7	1.8	1.8	1.9

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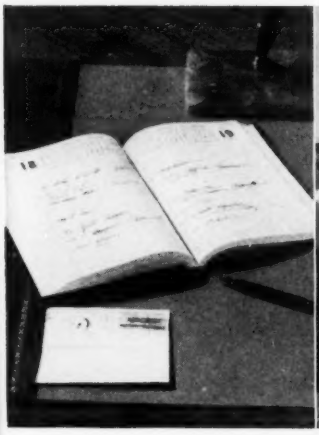

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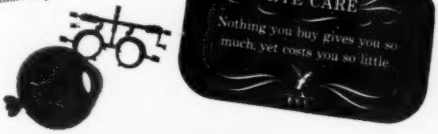

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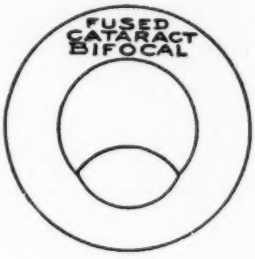

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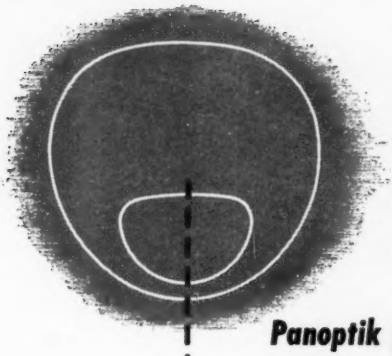

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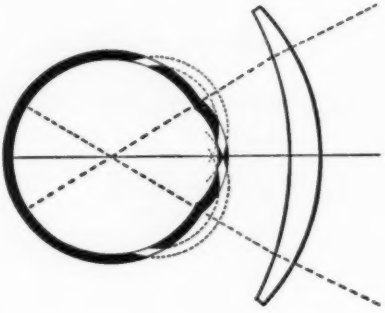

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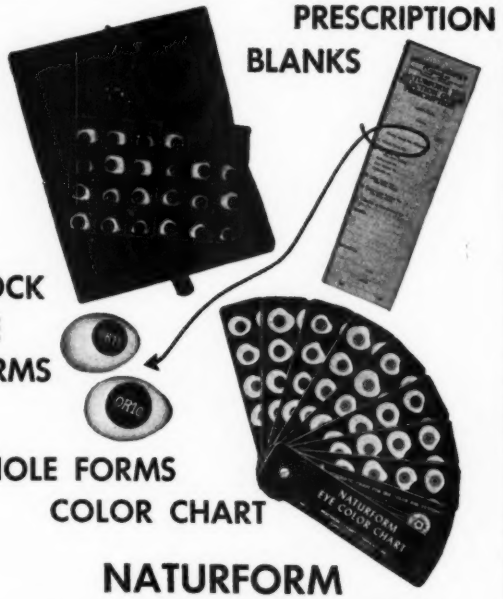

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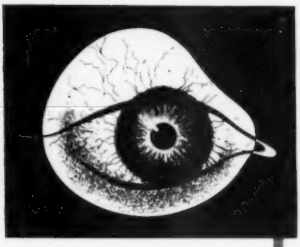

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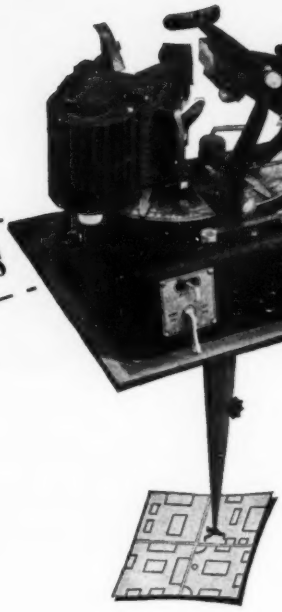

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ARCHIVES OF OPHTHALMOLOGY

VOLUME 42 AUGUST 1949 NUMBER 2

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HEREDITY AND RETINOBLASTOMA

ALGERNON B. REESE, M.D.
NEW YORK

IT HAS been well established that there is a strong hereditary tendency in retinoblastoma. Although the exact way in which the disease is transmitted has not been agreed on, evidence largely points to its being a dominant trait irregular in type. Some cases have been reported of collateral involvement in siblings whose parents were apparently normal, and many cases of direct transmission from parent to child.

There remains, however, the majority of cases in which the appearance of the neoplasm seems to be sporadic, no relative of the child having had the disease and the parents both having normal eyes. This sporadic type may be a somatic mutation arising from a developmental disturbance, but it must be borne in mind that should such a case be arrested the patient might well found a fraternity in which the growth would become a dominant trait.

Two questions of genetic interest in relation to retinoblastoma are frequently posed the ophthalmologist. First, when retinoblastoma has occurred in one child of healthy parents, what is the likelihood that further siblings will be affected? Second, is it advisable for the adult survivor of retinoblastoma to have children?

Many instances of the hereditary and familial occurrence of retinoblastoma have been documented in ophthalmic literature. Extensive bibliography on the subject can be found in the papers of Benedict,[1] Rados,[2] Weller,[3] Griffith and Sorsby,[4] and Falls.[5] Although reported

From the Institute of Ophthalmology of the Presbyterian Hospital and Memorial Center for the Treatment of Cancer and Allied Disease.

1. Benedict, W. L.: Retinoblastoma in Homologous Eyes of Identical Twins, Arch. Ophth. **2**:545 (Nov.) 1929.

2. Rados, A.: Occurrence of Glioma of Retina and Brain in Collateral Lines in Same Family, Arch. Ophth. **35**:1 (Jan.) 1946.

3. Weller, C. V.: The Inheritance of Retinoblastoma and Its Relationship to Practical Eugenics, Cancer Research **1**:517, 1941.

4. Griffith, A. D., and Sorsby, A.: The Genetics of Retinoblastoma, Brit. J. Ophth. **28**:279, 1944.

5. Falls, H. F.: Inheritance of Retinoblastoma (Two Families Supplying Evidence), J. A. M. A. **133**:171 (Jan. 18) 1947.

pedigrees definitely indicate a hereditary tendency, a mere tendency to a disease which is reputed to occur only once in 34,000 births may not be important. The literature on the subject concerns itself mostly with isolated cases which unquestionably show the hereditary trend but which are not adequate for statistics on incidence.

PRESENT STUDY

We communicated concerning 171 consecutive cases of retinoblastoma encountered at the Institute of Ophthalmology and the Memorial Center for the Treatment of Cancer and Allied Diseases. We were successful in receiving the desired data on 91 cases.

Series of Sporadic Cases, Showing Number of Siblings Involved

Author	No. of Cases	Instances of More Than One Sibling	Total No. of Children
Lawford, J. B., and Collins, E. T.: Roy. London Ophth. Hosp. Rep. **13**:12, 1890-1893	60	0	...
Marshall, C. D.: Roy. London Ophth. Hosp. Rep. **14**:456, 1895-1897	32	1	...
Owen, S. A.: Roy. London Ophth. Hosp. Rep. **16**:323, 1905-1906	32	1	...
Adam, C.: Ztschr. f. Augenh. **25**:330, 1911	44	3	...
Berrisford, R. D.: Roy. London Ophth. Hosp. Rep. **20**:296, 1915-1917	41	0	...
Davenport, R. C.: Brit. J. Ophth. **10**:474, 1926	27	0	...
Hemmes [7]	48	0	211
von Heijl, C.: Acta Ophth. **12**:69, 1934	60	0	...
Stock, W.: Ber. d. d. Versamml. d. deutsch. ophth. Gesellsch. **51**:106, 1936	28	0	...
Reiser [6]	16	0	64
Keller, P.: Arch. d'opht. **2**:813, 1938	13	0	...
Lange, H.: Klin. Monatsbl. f. Augenh. **10**:854, 1938	35	0	...
Griffith and Sorsby [4]	53	1	...
Our series	86	1	103
Total	605	7	378

Eighty-six cases were sporadic (cases in which both parents were healthy) and 5 cases were collateral (the patients were the progeny of parents one of whom was a retinoblastoma survivor).

Sporadic Cases.—For 60 of the 86 sporadic cases the siblings totaled 103. Only 1 sibling of these 103 had retinoblastoma. There are a number of large series of sporadic cases in the literature, and the data on some of them, including our own, are shown in the table. It can be seen that of 605 sporadic cases there were 7 in which siblings were affected. However, because the total number of siblings was indicated only in three series (those of Reiser,[6] Hemmes [7] and ours), percentages on the likelihood of the occurrence of retinoblastoma in siblings

6. Reiser, K. A.: Bemerkungen zur Erblichkeitsfrage beim Glioma retinae, Klin. Monatsbl. f. Augenh. **99**:350, 1937.

7. Hemmes, G. D.: Untersuchung nach dem Vorkommen von Glioma retinae bei Verwandten von mit dieser Krankheit behafteten, Klin. Monatsbl. f. Augenh. **86**:331, 1931.

must be based entirely on these three series, which together comprise 150 cases in children, who had a total of 378 siblings. Among these siblings there was only 1 case of retinoblastoma, making the incidence less than 2.9 in 1,000. Analysis of the data in our series by the method of the confidence range indicates that if 1 of 103 siblings had retinoblastoma there is a 95 per cent likelihood that the true range lies between zero and 4 per cent of siblings of patients with retinoblastoma born of healthy parents. The use of the total of 378 siblings (in the three series) would, of course, yield a considerably lower confidence range. An analysis, therefore, of several series of unselected cases of sporadic retinoblastoma indicates that the likelihood that a second sibling will be affected is less than 4 per cent, and is probably nearer 1 per cent. I do not hesitate, therefore, to advise healthy parents who have had one child with retinoblastoma to have more children.

Collateral Cases.—No statistical analysis has been made of any appreciable number of parents who have themselves survived retinoblastoma, and therefore an accurate measure of the likelihood of transmission of the disease from a surviving parent to a child is not possible.

Reiser [6] in 1937 indicated that of thousands of cases, with an approximate survival rate of about 50 per cent, there were probably hundreds in which the patient reached the reproductive age, but at that time only 20 to 25 cases of verified transmission had been reported. He stated, therefore, that the transmission rate was not high enough to warrant the sterilization of retinoblastoma survivors.

However, in our experience with retinoblastoma we have had 5 instances in which the progeny of survivors of retinoblastoma had retinoblastoma. These were briefly as follows:

Case 1 (N. D.).—The father had had both eyes enucleated in infancy because of retinoblastoma. His only child had bilateral retinoblastoma, and bilateral enucleation was done. The child survived and is now 10 years old.

Case 2 (M. S. D.).—The father had bilateral retinoblastoma and bilateral enucleation in infancy. He was told that it would be safe to have children. The first child had bilateral retinoblastoma, for which bilateral enucleation was done, and she now survives, after eight years. Before the fate of the first child was known, a second child was conceived. This child also had bilateral retinoblastoma, for which an enucleation of the eye with the more advanced lesion was done. The fellow eye was treated with roentgen radiation.

Case 3 (M. J. C.).—The father had an eye enucleated in infancy because of a tumor (presumably a retinoblastoma). His first child died of retinoblastoma. The second child is living and well. The third child had bilateral retinoblastoma. One eye had to be enucleated, and the other was treated by irradiation.

Case 4 (C. G. and M. G.).—The father had one eye enucleated in infancy because of retinoblastoma. His first child had bilateral retinoblastoma. One eye was enucleated, and the other was treated with roentgen radiation. His second

child also had bilateral retinoblastoma. Because of the advanced stage of the tumor, both eyes had to be enucleated.

CASE 5 (R. V.).—The mother had one eye enucleated at the age of 2 years. Her only daughter had bilateral retinoblastoma. The child died because of intracerebral extension of the tumor.

We have in our series of 184 cases of retinoblastoma only 5 survivors with children. The children total 8, and 7 of these had bilateral retinoblastoma. These figures are sufficiently impressive to me to interdict the bearing of progeny by all survivors of retinoblastoma.

CONCLUSIONS

1. There is no contraindication to healthy parents who have had one child with retinoblastoma having more children.

2. A survivor of retinoblastoma should not have children.

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ELMER A. SHAW, M.D.
BOSTON

FOR MANY years artificial fever, induced in the hypertherm cabinet or by single injections of foreign protein or typhoid vaccine, has been used in the treatment of various diseases of the eye. In the past decade attention has been directed particularly toward the use of single, rapid intravenous injections of typhoid vaccine. A drawback of this type of therapy is the unpredictable febrile reaction. In some cases extremely severe chills and high fever occur, whereas in others several injections are required, over a period of days, before the proper degree of fever is secured. Moreover, typhoid therapy is frequently withheld from elderly patients or persons with heart disease because of the risk entailed in a severe reaction. Solomon and Somkin [1] in 1942 introduced the method of controlled hyperpyrexia by the continous intravenous administration of typhoid vaccine. It occurred to us that this type of therapy might well be applied to the treatment of certain ophthalmic diseases.

MATERIALS AND METHODS

One cubic centimeter of typhoid vaccine in a concentration of 1,000,000,000 killed organisms per cubic centimeter was suspended in 1 liter of sterile isotonic sodium chloride solution U. S. P. With the patient recumbent in bed, a 21 gage intravenous needle was inserted in an antecubital vein and the mixture allowed to flow at a rate of 20 to 30 drops per minute. Rectal temperatures were recorded at fifteen minute intervals. If the temperature did not begin to rise in thirty to forty-five minutes, the rate of flow was doubled. On the other hand, if the rise in temperature was rapid, the rate of flow was decreased. The degree of fever desired varied from case to case, depending on the condition under treatment and the physical condition of the patient. In aged or debilitated patients and in those with notable arteriosclerosis, chilling and hyperpyrexia were avoided by

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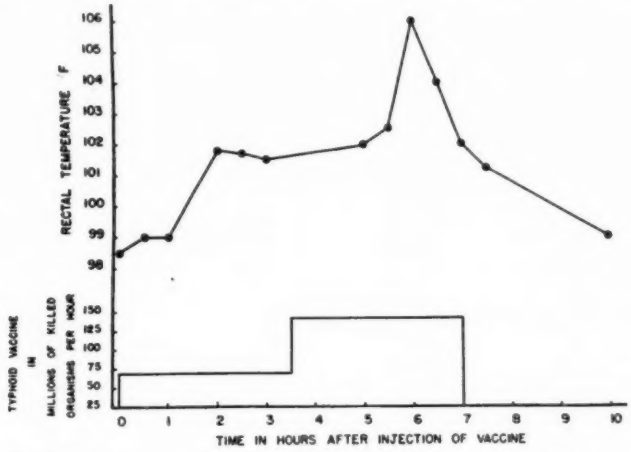
1. Solomon, H. A., and Somkin, E.: An Improved Method of Obtaining Sustained Controlled Hyperpyrexia with Triple Typhoid Vaccine, Am. J. M. Sc. **203**:736, 1942.

using very slow rates of infusion. With other patients, those with syphilitic keratitis, for example, it seemed desirable to have a temperature over 102 F., and preferably over 104 F., for several hours.

If improvement was not pronounced within forty-eight hours after treatment, a not uncommon occurrence, a second continuous injection of typhoid vaccine was given. With the second course of therapy the rate of flow was frequently more rapid. When the patient was subjected to sustained hyperpyrexia, from 50 to 100 mg. of meperidine hydrochloride (demerol hydrochloride®) was given intramuscularly prior to the administration of the typhoid vaccine. The only other medication employed was local instillation of atropine sulfate ointment.

RESULTS

Fourteen patients with nonspecific iritis were given continuous intravenous injections of typhoid vaccine over periods of four to twelve hours. Eight patients required only one course of therapy. Of these,



Correlation of temperature response and administration of typhoid vaccine (patient S. K.).

2 showed pronounced to complete improvement in twenty-four hours, whereas the other 6 required forty-eight hours to attain a similar result.

Patient S. K., of this group of 8 patients, was especially interesting because despite two single intravenous injections of typhoid vaccine an increased exudate in the anterior chamber occurred and the condition of the eye became worse. However, within twenty-four hours after a single course of continuous typhoid vaccine therapy, with about eight hours of fever and a maximum temperature (rectal) of 106 F. (figure), the exudate cleared and the eye became much whiter. The remaining 6 patients required a second course of therapy because

improvement was not satisfactory. Within forty-eight hours after the second injection, however, all the patients had shown pronounced to complete improvement.

In 4 of the 14 patients with iritis, because of debility and age or disease of the coronary arteries, the typhoid vaccine in sodium chloride solution was given very slowly, so that no chilling occurred and the temperature did not rise above 102 F. (rectal). Two of these patients required an additional course of therapy, but, so far as could be determined, in this small group, improvement was just as prompt as in the patients treated with prolonged high fever.

Two patients with suspected sympathetic ophthalmia were given continuous intravenous therapy of typhoid vaccine; the first patient showed clearing within twenty-four hours after one course of therapy, whereas the second required two courses.

In 1 patient with syphilitic keratitis two bouts of fever were induced, a total of nine hours with a temperature over 103.6 F. (rectal). Clearing took place within forty-eight hours of the second course of therapy.

COMMENT

While little is definitely known concerning the mechanism of improvement following the administration of typhoid vaccine, it has generally been assumed that the degree of fever is the important factor. Indeed, this belief has led to the widespread use of the hypertherm cabinet. However, the results of therapy in some of our patients, in whom very slight fever was induced, indicate that fever may not be the only important factor.

In any event, the continuous intravenous administration of typhoid vaccine appears to be superior to single injections of typhoid vaccine because the results are predictable and the degree of fever and chilling may be controlled. This type of therapy may be given safely to elderly and debilitated patients and to persons with coronary arteriosclerosis. A disadvantage is that intravenous drip apparatus is necessary and the administration of the vaccine must be carefully supervised.

SUMMARY

A total of 17 patients with ophthalmic diseases, including nonspecific iritis, syphilitic keratitis and suspected sympathetic ophthalmia, were treated by the continuous intravenous administraton of typhoid vaccine, with gratifying results in every case. This method of treatment is recommended because it may be given safely to elderly and debilitated patients and the degree of fever and chilling may be controlled.

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MINIMAL DEFECTS IN VISUAL FIELD STUDIES

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INTRACRANIAL lesions that interfere with the visual pathways will cause defects in the visual fields, the extent depending on the amount of interference. When such interference is great enough, the field defect produced is correspondingly large and is easily elicited with routine perimetric studies and even by confrontation. Since the presence of field defects is often an important means of localizing, lateralizing or even recognizing the presence of an intracranial lesion, it is important to be able to detect any defect in the visual field, however small. Such small defects are often difficult to detect and the recognition of some of them will be discussed in the present paper.

In order to recognize minimal defects, one must use minimal stimuli for the various isopters being tested. In other words, if one wishes to explore a certain part of the field for slight defects, one must use the smallest stimulus which is normally known to be just recognized in this particular arc of the field.

For minimal peripheral defects, a 5/330 or 3/330 test object may be used. However, it has been my experience that a 1/330 test object will often bring out a defect that will be missed with a 5/330, a 3/330 or even a 2/330 test object, and at the Montefiore Hospital the 1/330 test object has, therefore, become a favorite for detecting minimal defects in the peripheral field. For the recognition of early or minimal defects in the more central isopters, the 1/2,000 test object is a good minimal stimulus to use. This test object, if used to full advantage, can usually be made to bring out the most central and minimal defects, although one can supplement such delicate testing with 0.5/2,000 white and 2/2,000 red for the inner 2 degrees of field for lesser defects, if necessary.

For practical purposes, therefore, the 1/330 test object has been used for study of the peripheral fields and the 1/2,000 test object for study of the central fields in order to detect minimal defects.

In using these minimal stimuli, if one merely brings the test object along the various meridians and records the readings mechanically,

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From the Ophthalmological Service of Dr. Samuel Gartner and the Neurosurgical Service of Dr. Leo M. Davidoff, Montefiore Hospital for Chronic Diseases.

one is apt to miss small defects. Rather, the technic must be guided by the clinical features of the case, as an indication of what to look for. One of the commonest features sought in interference due to intracranial lesions is incomplete hemianopsia, whether homonymous, temporal or bitemporal. In order to recognize such early hemianoptic

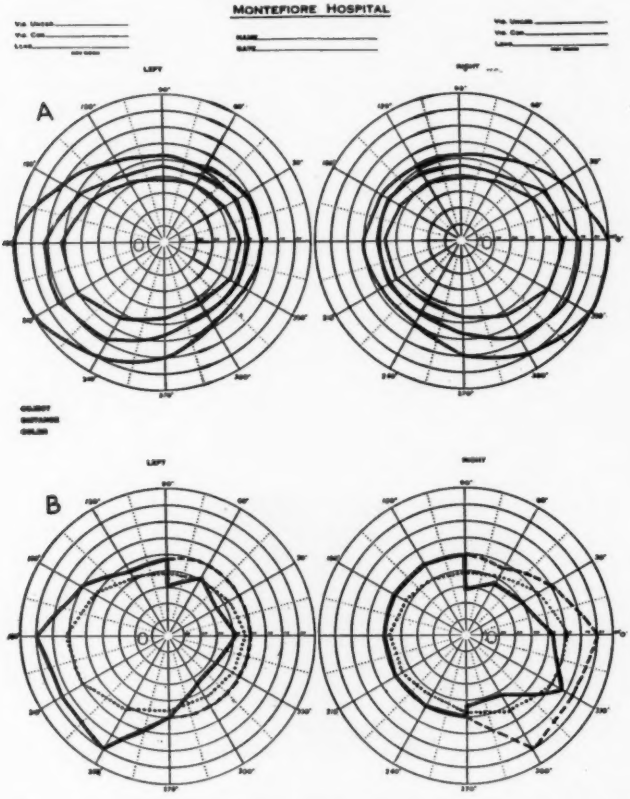

Fig. 1.—*A*, Montefiore chart for peripheral fields. The isopters for 5.8/330, 3/330 and 1/330 white are shown. These isopters are actually represented by pale green lines, which to the casual glance are barely perceptible against the white paper and the accompanying deep orange meridional and arc markings. For purposes of this photograph, the isopter lines have been accentuated with black ink.

B, right homonymous hemianoptic defect, as shown by level differences and breadth of field. The explanation of these lines will be found in the text of this article.

defects, I use three sets of criteria in examination and interpretation: (1) level differences, (2) rapid comparisons for qualitative differences, and (3) breadth of field.

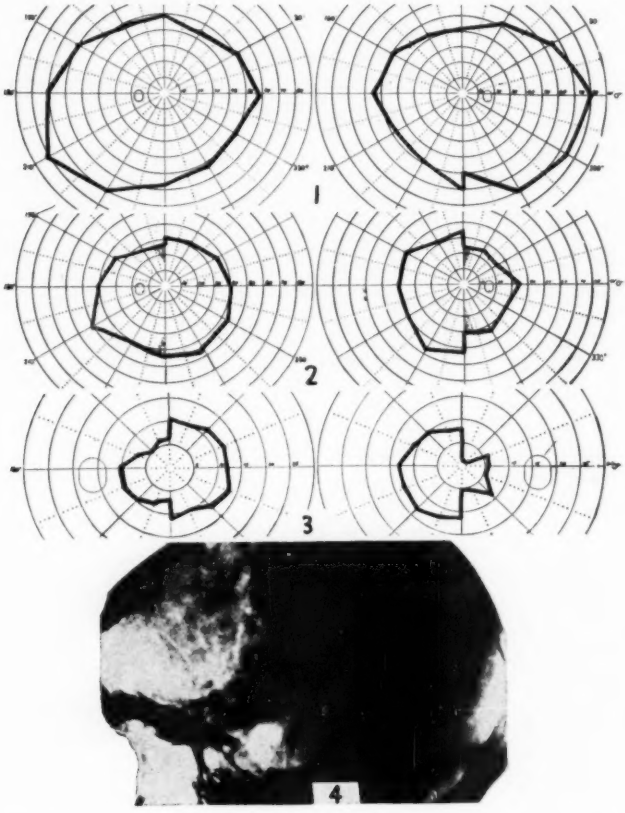

Fig. 2 (case of adenoma of the pituitary gland).—*1*, practically normal fields for 3/330 white except for a single level difference in the 270 degree meridian of the right eye. *2*, peripheral field for 1/330 white, showing qualitative defect on the temporal side of all the vertical meridians. This defect was elicited by rapid comparisons and is indicated by stippling in those areas. The left eye also shows a small level difference in the 90 degree meridian. Larger level differences are seen in both vertical meridians of the right eye. *3*, bitemporal field defect for 1/2,000 white. These defects are no longer minimal. *4*, large, eroded sella turcica.

All these field studies were made at the same examination.

LEVEL DIFFERENCES

By level differences, I refer to slight differences of extent of field on the left and the right sides of the vertical meridians, giving a step-like appearance to the field of vision at the vertical meridians. These

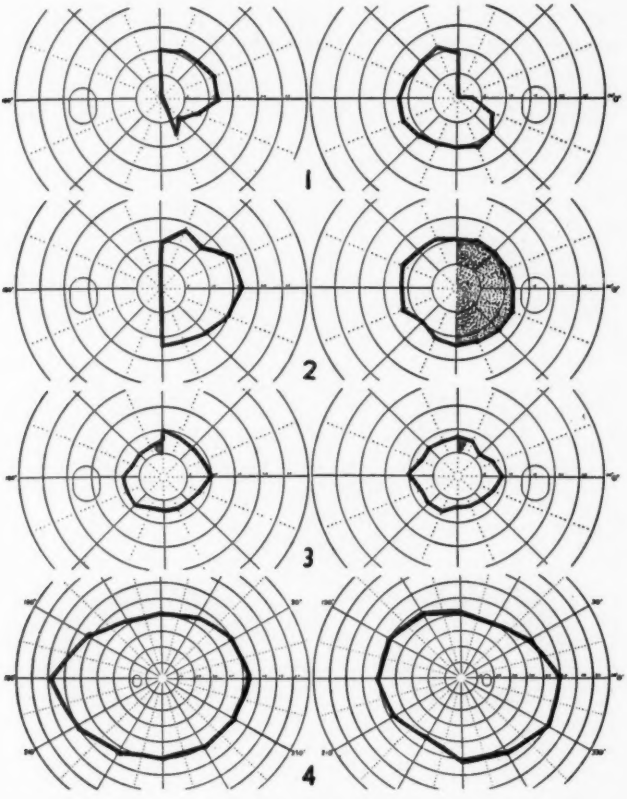

Fig. 3 (case of adenoma of the pituitary gland).—*1*, preoperative field for 1/2,000 white, showing bitemporal hemianoptic defect. *2*, 1/2,000 fields on the eighth postoperative day. The left eye shows a return of the lower nasal field with improvement of visual acuity from 15/40 to 15/15. The right eye shows a return of temporal field, although of a relative nature. The relative quality of this temporal field was brought out by rapid comparisons. *3*, field for 1/2,000 three months after operation. The left eye still shows some level difference and qualitative difference brought out by rapid comparisons. The right eye shows only a qualitative difference above. *4*, peripheral field for 1/330 white, taken at the same time as the fields in *3*, showing absence of any defect.

differences may be as little as 5 degrees on the perimeter and only 2 degrees on the 2 meter screen. Some observers may believe that such small differences are within the limits of error in technic. However,

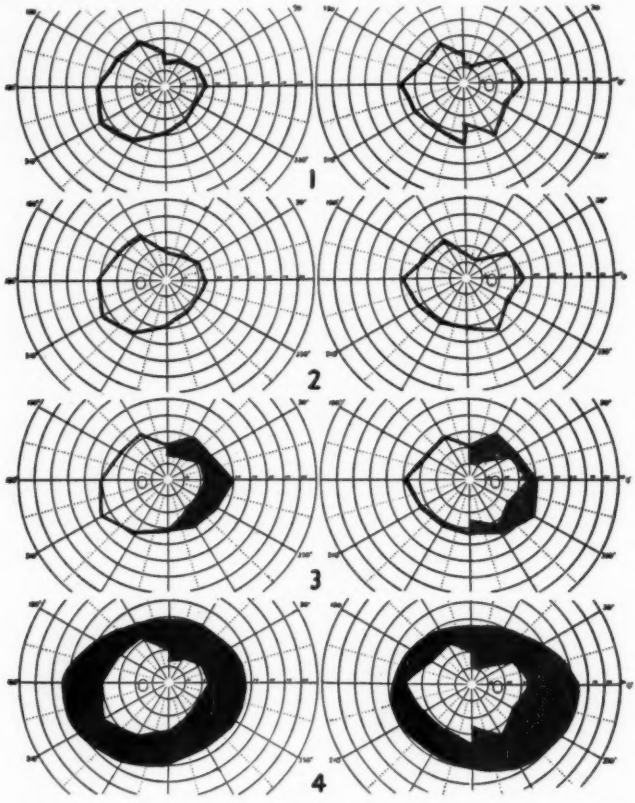

Fig. 4 (case of meningioma of the left temporoparietal area).—*1*, peripheral fields for 1/330 white, showing level differences. *2*, the same fields plotted in the usual way without bringing out level differences. Such fields, on casual examination, may pass as showing only generalized peripheral contraction. Actually, even these fields show a right homonymous defect on comparison of the two nasal fields and the two temporal fields. *3*, a larger temporal field in the left eye and a larger nasal field in the right eye, as evident from measuring breadth of field. When these larger half-fields are used as normals, the plotted fields show a right homonymous defect. *4*, picture produced by actual plotting of these fields on the Montefiore chart and filling in to the appropriate isopter. These fields demonstrate the right homonymous defect determined both by level differences and by breadth of field. In addition, they show a generalized peripheral contraction, undoubtedly due to prolonged intracranial pressure.

if consistently found, they must be considered significant. The side of the lesser reading is likely to be that of a defective hemianoptic field. In eliciting these level differences, one must test the field on each side of the vertical meridian independently and make the recordings for the nasal and the temporal side separately. These recordings are placed on the vertical meridian of the chart and connected by a straight line, the upper and lower ends of which will subsequently be connected

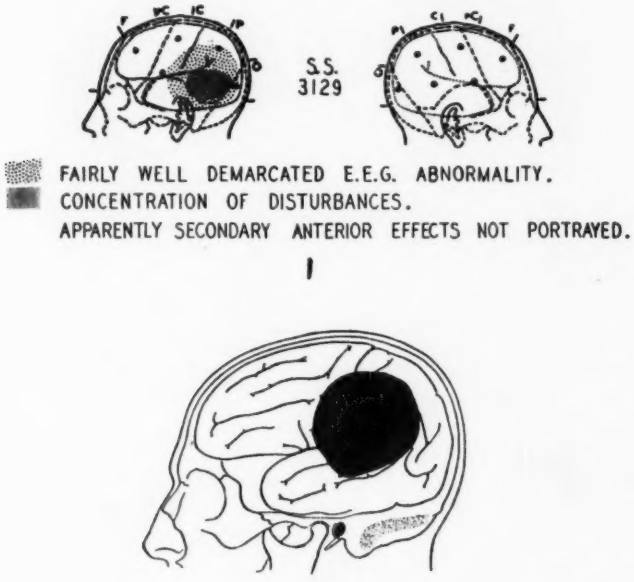

Fig. 5.—Additional clinical data in the case the fields of which are shown in figure 4. *1*, area of disturbance as determined by electroencephalography. *2*, surgeon's sketch, showing site of tumor as found on operation.

with the proper points found on the adjoining nasal and temporal meridians.

In figures 1*B*, 2, 3, 4, 6, 7 and 9, there are fields showing the small but constant level differences on the nasal and the temporal side of the vertical meridians. If these level differences had not been looked for and recorded, the fields could easily assume a rather normal-looking pattern and pass as normal to the inexperienced eye.

For example, in figure 6, *1* illustrates the actual field found by determining the level differences in the vertical meridians; *2* in the same figure shows what the field would look like if one had explored the vertical meridians merely along the center of the perimeter arc, without bothering to explore each side of the vertical meridian separately. Similar examples are shown in figures 4, 7 and 9.

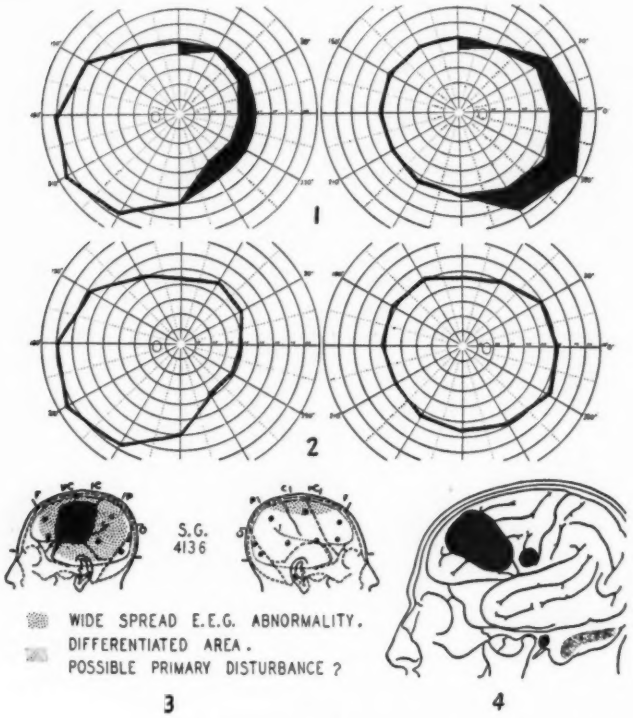

Fig. 6 (case of metastatic tumor involving an area of the left cerebrum, but showing only minimal interference with visual pathways).—*1*, fields filled in, showing minimal right homonymous hemianoptic defect, determined both by level differences and by breadth of field. *2*, same fields plotted without measurement of level differences. The rounded right peripheral field should lead the examiners to suspect a temporal peripheral defect. *3*, areas of abnormality as determined by electroencephalography. *4*, surgeon's postoperative sketch, showing the most apparent area of the mass.

In testing on either side of the vertical meridians of the perimeter or the tangent screen, one should keep well away from the meridian

proper, especially if fixation is not very good. The more reliable the patient and his fixation, the closer the examiner dares to bring the test object to the 90 degree or the 270 degree meridian on each side. With the narrow perimeter arcs, one may start moving the test object very well near the edge of the perimeter arc peripherally and bring it in radially toward fixation. With the wider perimeter arcs, such as the Brombach, one must stay farther in from the edge since the

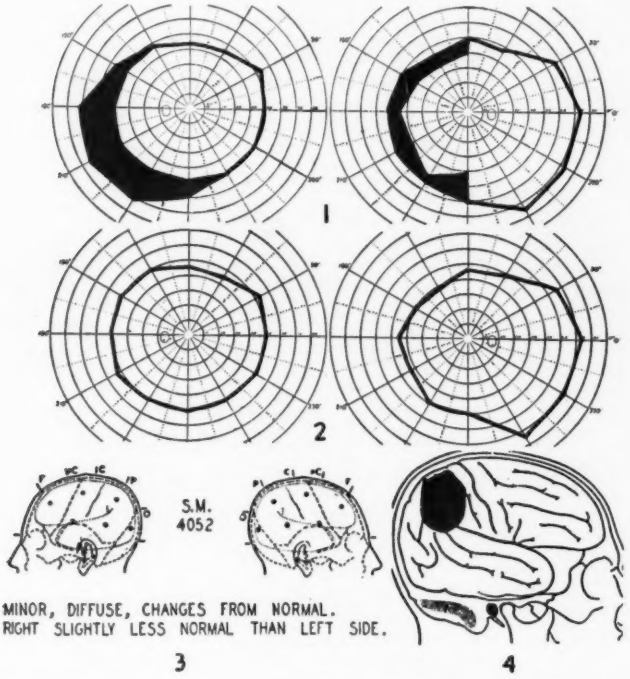

Fig. 7 (case of tumor in right parieto-occipital area).—In this case, prior to air studies, there was a question of lateralization. *1*, peripheral fields for 2/330 white, showing left homonymous hemianoptic defect, both by level differences and by breadth of field. *2*, fields as plotted without level differences. These fields might easily pass as normal to casual observation. However, the rounded left peripheral field should arouse suspicion of a temporal defect. Even in this plotting, the left homonymous hemianoptic defect may be recognized by comparing the breadth of field in the corresponding halves of the two eyes. *3*, results of electroencephalography, showing only very little disturbance, without definite localization. *4*, surgeon's postoperative sketch, showing location of tumor on the right side.

width of the perimeter is such that one would actually be testing about 10 degrees off the vertical meridian near the periphery.

Even though these level differences are very small, if they are constant and form the picture of a definite field defect that is in keeping with the rest of the clinical picture, one may feel quite sure of their significance. A definite level difference in the 90 degree meridian for the 1/2,000 test object may be the first evidence of a beginning temporal defect due to chiasmal interference.

RAPID COMPARISONS FOR QUALITATIVE DIFFERENCES

This method makes use of a single test object to examine different parts of the field in which it is seen for small amounts of defect. Thus, while the 1 mm. white test object may be recognized throughout all the 15 or 20 degrees of field on the 2 meter screen, by rapidly shifting

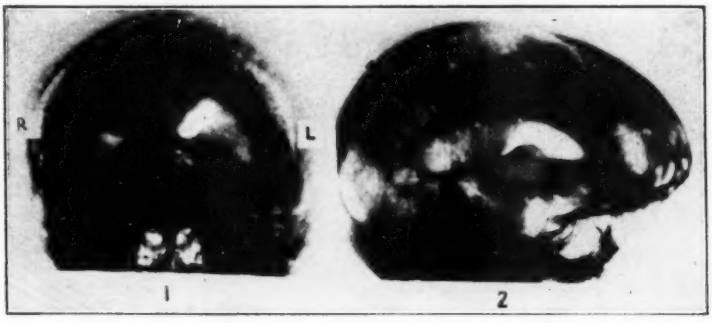

Fig. 8.—Roentgenograms in the case fields for which are shown in figure 7. *1*, right lateral ventricle, smaller and pressed down as by a mass from above; *2*, lateral view, showing smaller right ventricle being pressed down from above and behind.

the test object from the nasal to the temporal side of the vertical meridian, at comparable levels and distances from the meridian, where visual acuity should normally be the same on the two sides, one may be told by the patient that the test object is definitely much clearer and more definite on one side than on the other. This difference may be considered a relative defect for that particular visual angle on the side of poorer vision and as corroboration of the existence of a hemianoptic defect. Similarly, a minimal defect in the cecocentral area of optic neuritis may be brought out by rapidly comparing the perception of the test object on the horizontal meridian in the cecocentral area with its visibility a little higher up or lower down. Also, a relatively mild Bjerrum scotoma may be picked up by bringing out

a definite difference in perception above and below the nasal horizontal meridian. In all these conditions, if the defective area is not very dense, merely bringing the test object along slowly from good field to poor field, or vice versa, will not bring out the small defect, while by suddenly displaying it in good field and rapidly changing it to poor field one will bring out the difference quite readily, even though it is a small one. I use this method of rapid comparisons routinely with the 1/330 as well as the 1/2,000 test whenever I examine the vertical meridians for hemianoptic defects.

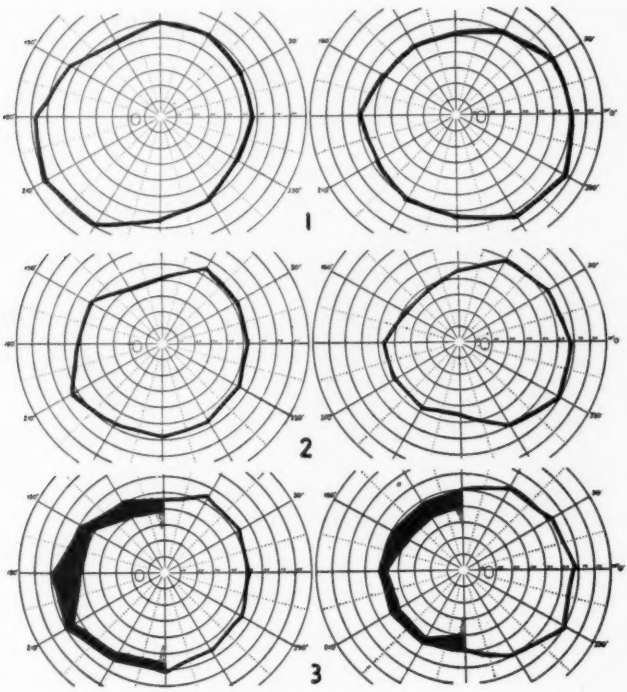

Fig. 9 (case of meningioma of the right frontotemporal area).—*1*, peripheral fields for 2/330 white. Although looked for, no level differences could be found with this visual angle. *2*, peripheral fields for 1/330 white, plotted without effort to obtain level differences. These fields may pass as not remarkable on casual inspection. However, comparison of corresponding halves for breadth of field reveals definite left homonymous defect. *3*, peripheral fields for 1/330 white showing level differences and differences in breadth of field, both pointing to a left homonymous hemianoptic defect. In addition, rapid comparisons corroborated these findings. In all four vertical meridians, at the periphery, the patient saw the test object less clearly on the left side than on the right. This is indicated by the stippling in the defective areas.

Besides the 1/330 and the 1/2,000 white, a good test object for rapid comparisons is the 5/2,000 red. Often, this test object will be called "red" in the good field and "pink" in the other, or, in poor fields, "pink" on one side and "grayish" on the other.

In using rapid comparisons on the perimeter, it is well to bring the test object in 5 or 10 degrees from the periphery of the field before alternating the test object in the two areas being compared. This has the advantage that better fields are compared than the very poor fields at the extreme periphery. An example of information brought

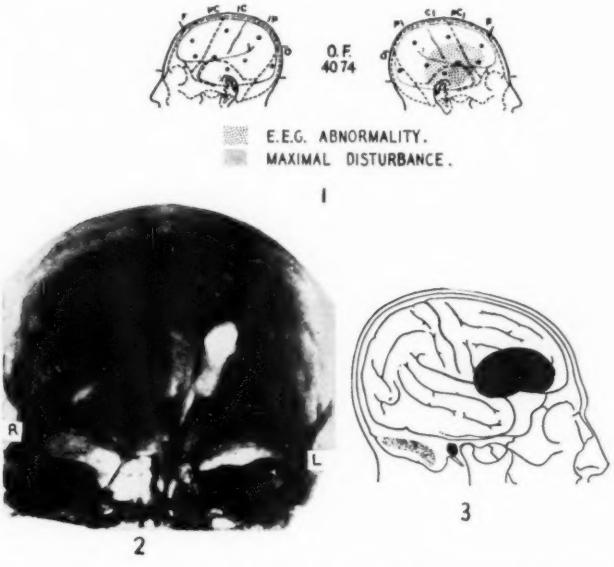

Fig. 10 (additional clinical data in case fields of which appear in figure 9). —*1*, area of greatest disturbance as determined by electroencephalography. *2*, roentgenograms showing right lateral ventricle pushed over to the left side, apparently by a space-occupying mass on the right side. *3*, surgeon's postoperative sketch, showing the right frontotemporal location of the tumor.

out by rapid comparisons is found in *2* of figure 2. Here, the 1/330 field for the left eye shows definitely worse vision on the temporal side of the 90 and 270 degree meridians, while there is no level difference below and only a slight one above. In the same figure, the 1/330 field for the right eye shows qualitative differences temporally near both vertical meridians, thus corroborating the larger level differences. These qualitative differences brought out by rapid com-

parisons corroborate the level differences and the resultant bitemporal hemianopsia. Another example of the use of "rapid comparisons" is seen in figure 3, *2*. Here, four months after the removal of a pituitary tumor by Dr. Leo Davidoff, the level difference in the field of the right eye is no longer present, but when the 1 mm. test object was rapidly alternated from the nasal to the temporal side the patient persistently saw it as clearer on the left side (nasal) than on the right side (temporal), this difference being the only remaining evidence of the temporal hemianoptic defect present before operation. These areas of relatively poor vision are indicated on the charts by stippling and may be considered relative scotomas for the particular visual angle being used.

Of course, instead of this technic, one could use progressively smaller test objects until one found an object still visible in one part of the field but no longer in the other. This is often a lengthy and painstaking process and is not of real practical value. From a clinical point of view, the method of rapid comparisons is highly satisfactory, even though the exact amount of defect is not labeled accurately in terms of visual angle and absoluteness.

BREADTH OF FIELD

A third method of evaluating minimal field loss is by comparing the field with the normal field for the particular visual angle. The normal fields for the 5.8/330 and 1.0/330 test objects were carefully worked out by Ferree, Rand and Monroe[1] a number of years ago, and I have made use of their findings in designing the Montefiore chart showing the median normal isopters for three commonly used visual angles. This chart is shown in figure 1*A*. The three isopters marked off represent the median normal fields for 5.8/330, 3/330 and 1/330 white. I have discussed the use of this chart and method of filling in lost field in a recent article.[2] Depending on age and refractive error, contraction beyond these median normal isopters may be considered pathologic. However, in many cases the field plotted may be much larger than the accepted normal. In such cases, if the visual acuity and refractive error are approximately equal in the two eyes, one may reasonably expect the two nasal fields and the two temporal fields to be approximately equal in size, and I make use of this principle in computing loss of field. Therefore, if there is gross inequality in

1. Ferree, C. E.; Rand, G., and Monroe, M. M.: Diagnostic Scales with the One Degree and 0.17 Degree Form Field Stimuli for Principal Meridional Quadrants Taken Separately, Arch. Ophth. **6**:518 and 534 (Oct.) 1931.

2. Chamlin, M.: Recording of Visual Fields, Am. J. Ophth. **3**:565 (May) 1948.

these corresponding fields, the smaller nasal field and the smaller temporal field may be considered defective.

Figure 1 *B* illustrates the method whereby I make use of this principle. Here, the heavy continuous line illustrates the field for 1/330 as actually found. The dotted line represents the median normal field for 1/330 white as found by Ferree, Rand and Monroe. It is obvious that the fuller temporal field of the left eye is not likely to have the small nasal field of the given normal as does its corresponding half. Rather, the normal nasal field for that person is likely to be correspondingly fuller than the median normal represented by the dotted line. Such a fuller nasal field may be assumed from the larger nasal field of the right eye, and it is seen that such a composite field is a more normal-looking peripheral field. Correspondingly, the normal temporal field of the right eye may be borrowed from the fuller temporal field of the left eye. These borrowed normal fields are shown in lines of dashes. In such cases, one may fill in the lost field up to the fuller normal fields of the patient's corresponding half-fields of the fellow eye, rather than up to the median normal fields of Ferree, Rand and Monroe. This principle is used in filling in the lost field in *3* of figure 9. Here, I made use of the patient's fuller half-fields in evaluating loss of breadth of field. Thus, breadth of field defects may be based on comparison with the normal fields as found by Ferree, Rand and Monroe, or on comparison with the fuller, corresponding halves of the patient's own fields.

It is interesting to note that in *2* of figure *7* the field of the left eye is almost perfectly round. Similarly, in *2* of figure *6* the field of the right eye is almost perfectly round. One should note that in both these fields there is actually some loss of temporal periphery; as a general rule, it is well to suspect an evenly rounded peripheral field as having a temporal defect. The normal peripheral field is more likely to be ovoid, with the larger diameter running from upper nasal to lower temporal field and the shortest diameter at right angles to it. This rule is unlike the one for the more central isopters, such as the field for 1/2,000 white, where one is more apt to find a rather evenly rounded, circular field normally.

Lately I have used the principle of simultaneous stimulation in eliciting level differences. Instead of using the small test object alternately on the two sides of the vertical meridian, two similar 1 mm. white test objects are passed along each side of the vertical meridian at the same time. This may be done by using two independent test objects on separate carriers, the examiner standing behind the patient and using a separate hand for each holder. Another method is to use a small black "paddle" type of carrier with two white test objects on it instead of one, and separated by 1½ or 2 inches (3.7 or 5 cm.),

so that there is one test object on each side of the vertical meridian as the carrier is brought centrally. I have described both these types of test object holders in a previous article.[3] The separate holders are probably better because they allow the examiner to vary the distance between the two test objects and thus come in radially as fixation is approached.

The patient may notice the test object on one side sooner than on the other, producing a level difference. In addition, once the two test objects are noticed, the patient may give helpful information that the object is definitely "clearer" or "more distinct" "or "brighter" on one side than on the other. This is substantially an indication of better quality of vision on that side and corresponds to the qualitative differences elicited by rapid comparisons. This method of simultaneous stimulation shows promise of becoming very useful in eliciting minimal defects, but I have not yet studied it fully enough to present any cases at present.

Actually, level differences elicited in this manner are comparable to the so-called attention defect except that the stimuli are much smaller, and therefore much smaller defects should be elicited.

SUMMARY

Three criteria are presented for detecting minimal field defects—level differences, rapid comparisons for qualitative differences and breadth of field. When only one of these criteria points to a defect, and to a defect of small extent, one must be extremely cautious about the interpretation. If two criteria are fulfilled and they point to the same type of field defect, one may be surer of their significance. The fulfilment of all three criteria is highly reliable as evidence of a defective field.

It goes without saying that roentgenography, air studies, electroencephalography and angiography must be used to corroborate the perimetrist's minimal field findings. However, the ophthalmologist must never forget that perimetry, no matter how well done, is still a subjective test, and he must temper his interpretations with a practical and clinical sense in committing himself to his neurologic and neurosurgical colleagues.

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Dr. Margaret Rheinberger made the electroencephalographic studies used in this paper.

3. Chamlin, M.: Technical Methods for the 1/2,000 Field, Am. J. Ophth. **30**:1415 (Nov.) 1947.

MECHANISM OF CORNEAL WOUND HEALING

I. Cells Involved in Corneal Growth and Repair

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AND
PAUL E. MESSIER, M.D.‡
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IN SPITE of the large amount of clinical and laboratory research work [1] that has been done, very little is actually known about the mechanism of corneal wound healing and the cells involved in this healing process. To this end we have aimed our research: first, to identify the cells involved and, second, to learn the mechanism of corneal wound healing.

METHOD

A method has been worked out for maintaining rabbit corneal tissue in vitro apparently for an indefinite period. Fresh rabbit cornea is removed from the eye of the rabbit. The cornea is cut into pieces approximately 2 mm. square and 0.5 mm. thick. These pieces of tissue are planted in 3.5 D. Carrel flasks containing as a basic medium 0.7 cc. of Tyrode's solution, 0.3 cc. of rabbit serum, 0.5 cc. of chicken plasma and 1 drop of tissue extract of chick embryonic tissue (to facilitate formation of a coagulum). The cultures are kept in the incubator at a temperature of 38 C.

After twenty-four hours a supernatant layer of 0.5 cc. of rabbit serum is added to the cultures. The supernatant layer is removed after four days and the culture is washed with 0.1 cc. of Tyrode's solution for six hours, or even overnight. One-half cubic centimeter of fresh rabbit serum is then added. This procedure is repeated at four day intervals. After two weeks the cultures are divided and

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‡Lewis Cass Ledyard Jr. Fellow in Ophthalmology, with support in part from the Ettinger Fund.

The work of Mrs. Hoffman was supported in part by a grant from the Committee on Growth of the American Cancer Society.

1. Bajenova, M. A.: Culture of Preserved Corneal Tissue, Arch. d'opht. **53**:300, 1936. Castroviejo, R.: A Historical and Experimental Study of Keratoplasty, Including a New Method, Am. J. Ophth. **15**:825 and 905, 1932; Keratoplasty: Comments on Technic of Corneal Transplantation; Source and Preservation of Donor's Material; Report of New Instruments, ibid. **24**:1 and 139, 1941; Keratoplasty: Microscopic Study of the Corneal Grafts, Tr. Am. Ophth. Soc. **35**:355, 1937; Present Status of Keratoplasty, Arch. Ophth. **22**:114 (July) 1939. Filatov, V. P.: Transplantation of the Cornea from Preserved Cadaver's Eyes, Lancet **1**:1395, 1937. Elschnig, A., and Gradle, H. S.: History of Keratoplastic Operations to Date, Am. J. Ophth. **6**:998, 1923.

transplanted into fresh 3.5 D. Carrel flasks containing the same basic medium as that previously described and maintained in the same manner. Such cultures have been kept growing in our laboratory for fifteen months and are still in a healthy state. Addition of 0.5 cc. of an extract of adult sheep heart in Tyrode's solution possessing cell growth-promoting properties as a supernatant phase to the culture medium results in an area of growth approximately five times the size of that in cultures without cardiac extract.[2]

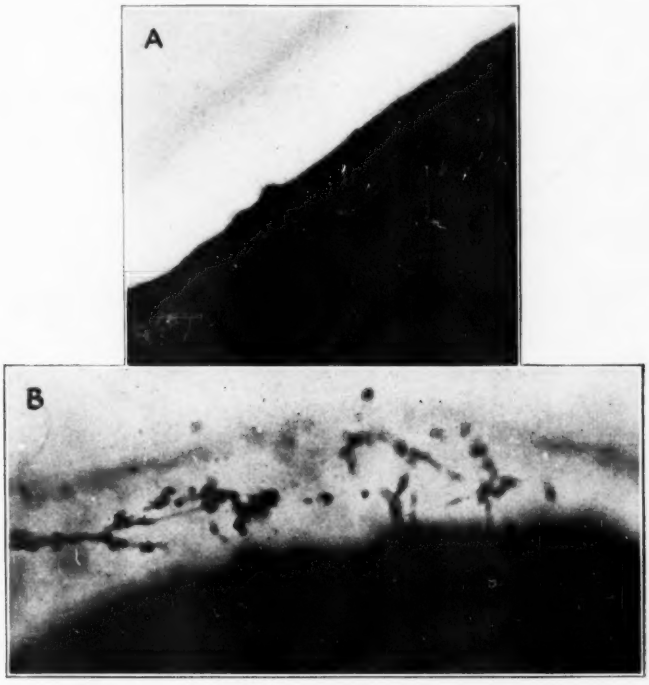

Fig. 1.—*A*, corneal tissue culture twenty hours after implantation. No cell division, proliferation or migration is present. *B*, corneal tissue culture twenty hours after implantation of cornea which had been irradiated with 30 r. Active cell division, proliferation and migration are present.

DESCRIPTION OF GROWTH

Latent Period.—When pieces of cornea are planted in vitro, as described, a period of from thirty to forty hours elapses before any

2. Hoffman, R. S., and Doljanski, L.: Growth Activating Effect of Extracts of Adult Tissue on Fibroblast Colonies in Vitro, Growth **3**:61, 1939. Hoffman, R. S., and Wohlman, G. H.: Unpublished Data, 1948.

cells appear at the margin of the explant. This period is known as the latent period. The latent period may be considerably shortened by irradiating the freshly implanted cultures with small doses of roentgen radiation (30 r) (kilovolts; 25 mm. tungsten target; 0.5 mm. copper plus 1.65 mm. aluminum filter). After such irradiation the latent period is reduced to from fifteen to thirty hours (fig. 1 *A* and *B*). It may also be mentioned that, whereas normally only approximately 60 per cent of the fresh corneal implants grow in vitro, 98 per cent of the irradiated implants showed growth.

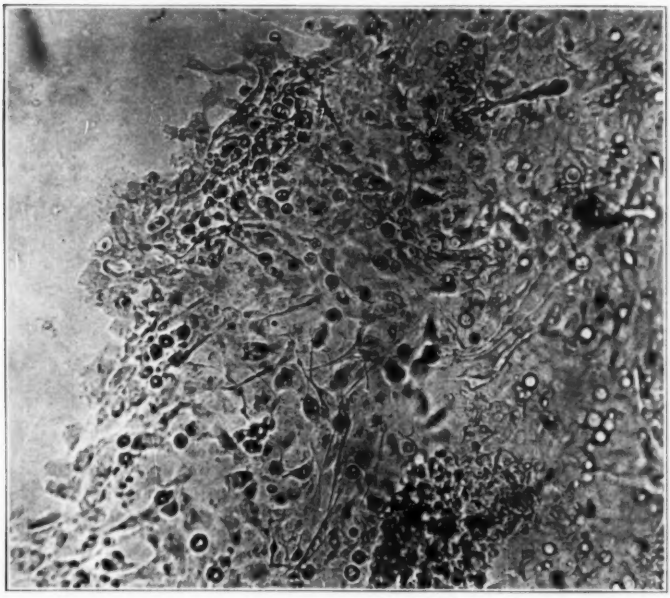

Fig. 2.—Corneal tissue culture fifty-four hours after implantation and treatment with growth-stimulating extract. Some epithelial cells are present, but the majority are corneal stroma cells, which vary in form from spindle to round cells. × 100.

Cell Types.—The first cells to appear are a mixture of epithelial cells, round cells and long, spindle-shaped cells, which are presumably the stromal cells, or keratoblasts. The growth of the epithelial cells lasts only a short time, and then they die out. By merely scraping the epithelium from the cornea before putting it in the tissue culture, one can entirely eliminate the growth of epithelium. A number of intermediate stages are observed between the round cells and the stromal cells, and

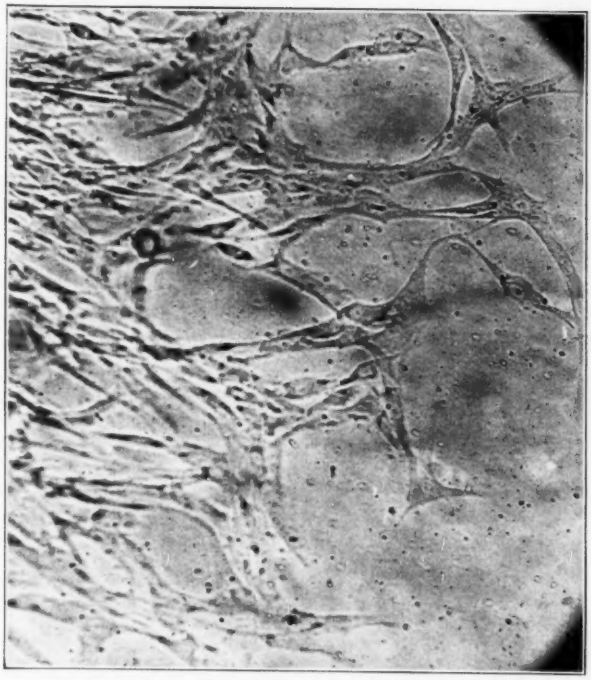

Fig. 3.—Corneal tissue culture eight months after the original implantation. The corneal stroma cells are now in the spindle cell form, and only a few round cell forms are present. × 100.

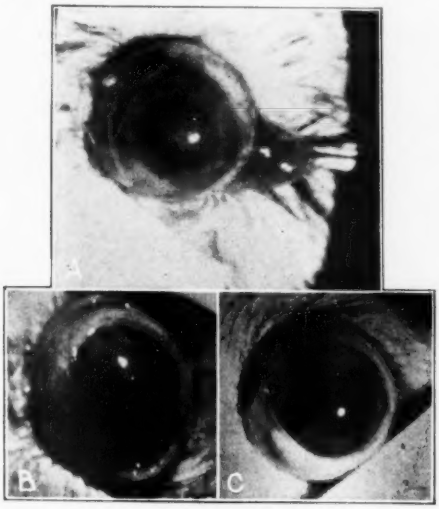

Fig. 4.—*A*, rabbit cornea one day after freezing of the entire cornea and the adjacent sclera with carbon dioxide snow. There is diffuse edema of the entire cornea with engorgement of the anterior ciliary vessels.

B, rabbit cornea four days after freezing of the entire cornea and adjacent sclera with carbon dioxide snow. Clearing of the cornea has begun at the limbus on all sides, and this clearing is extending in toward the center of the cornea.

C, rabbit cornea fourteen days after freezing of the entire cornea and adjacent sclera with carbon dioxide snow. The cornea has now completely regained its transparency, but corneal sensation does not return for four to six months.

this interchangeability can also be observed in response to changes in the temperature surrounding the tissue culture. Under normal conditions these cells have long, tapering spindle processes and a small, elongated nucleus and resemble fibrocytes very closely; but in response to environmental changes these cells appear to retract their processes and assume a round form, much like that of a large macrophage. This interchangeability in form of the cells lasts for about two weeks; then

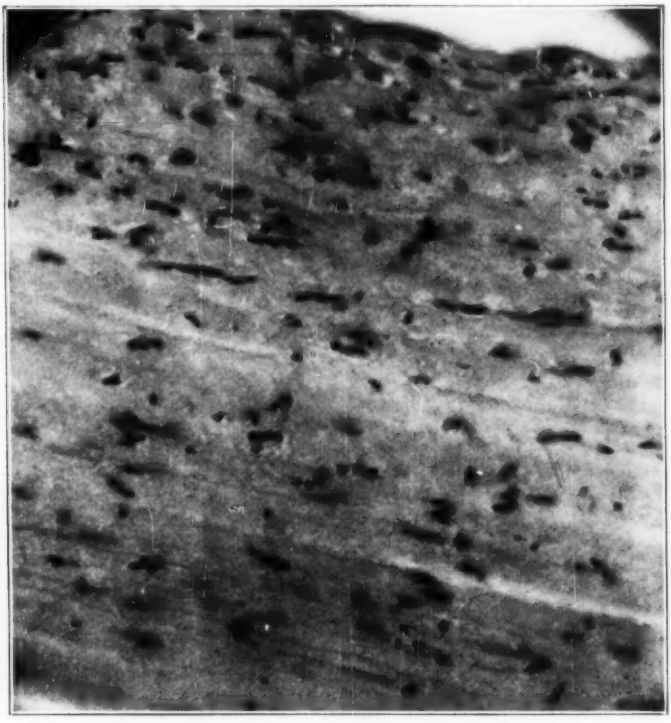

Fig. 5.—Cornea of eye enucleated four days after freezing of the entire cornea. No viable cells are present; only pyknotic and fragmented nuclear material are to be seen. Hematoxylin-eosin stain; × 450.

the fibrocytes take on the appearance of an almost pure strain of fibrocytes, with only a few round cells present (figs. 2 and 3).

CARBON DIOXIDE SNOW–FREEZING EXPERIMENTS

A brass container with a bottom 5 mm. square and 0.5 mm thick was devised to hold carbon dioxide snow for experiments in freezing the

cornea in the living animal. A portion of the cornea was frozen for one minute and then allowed to thaw out.

When the entire cornea and a portion of the adjacent sclera was frozen for one minute, forty-five seconds was required for the cornea to thaw out. Moderately severe edema involving all layers of the cornea developed within one hour (fig. 4 *A*). This edema persisted until the fourth day (fig. 4 *B*), when clearing was observed around the periphery of the cornea; and this clearing gradually widened toward the center of the cornea, until by the fifteenth day (fig. 4 *C*) the entire cornea was once again clear. For control purposes, portions of cornea

Fig. 6.—Cornea removed ten days after freezing of the entire cornea. Fibrocytes are entering the devitalized cornea from the limbus and are proceeding along lamellar interspaces. A few fragmented nuclei and empty cell spaces are still seen. Hematoxylin-eosin stain; × 450.

were removed immediately after freezing, and these portions of cornea were placed in tissue cultures, where no growth was observed at any time (fig. 5).

We assumed that the returning transparency of the frozen cornea was brought about by fibrocytes migrating from the surrounding fibrous structures into the devitalized cornea. After migrating into the devitalized cornea, these cells assumed the characteristics and functions of stromal cells. The areas of clearing paralleled the progress of the cells migrating into the devitalized cornea, and the areas which were not

invaded remained edematous and cloudy until the migrating cells reached this area. Sections of eyes removed at various times after freezing of the cornea showed these cells entering the periphery of the cornea, and the center of the cornea had no viable cells until the fifteenth day, when clearing was complete (fig. 6 and 7).

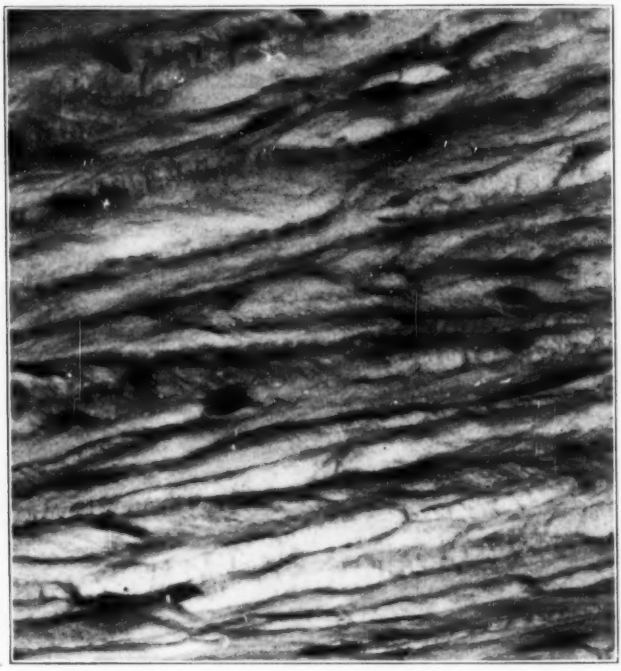

Fig. 7.—Cornea removed fourteen days after freezing of the entire cornea. The previously devitalized cornea has been completely repopulated by fibrocytes migrating from surrounding fibrous structures. With these invading cells also returns the transparency of the cornea. Hematoxylin-eosin stain; × 450.

SUMMARY AND CONCLUSIONS

A method was worked out for preserving rabbit corneal tissue in vitro indefinitely.

A pattern of growth of corneal stromal cells was observed. This pattern includes a definite latent period before any growth is observed and a noticeable interchangeability in form of the stromal cells in response to changes in environment.

The latent period of growth in the tissue cultures can be appreciably shortened by low dosage irradiation, and the amount of growth can be increased by the addition of aqueous sheep heart extract possessing stimulating properties to the tissue culture mediums.

The cells obtained on culture of corneal tissue exhibit the characteristics of fibrocytes.

The corneal stroma cells are not specific for the cornea but may be derived by migration from adjacent fibrous tissues. On entering the cornea, these cells, from adjacent fibrous structures, conform to the lamellar arrangement and assume the characteristics and functions of stroma cells.

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MECHANISM OF CORNEAL GRAFT HEALING

II. Behavior of Recipient and Donor Cells

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THE PURPOSE of this paper is to clarify the long-debated problem of the true nature of a corneal graft. The crux of the problem is whether a corneal graft heals like a skin graft, in other words like a "true" graft, or like a boiled bone or preserved cartilage graft, often called a "replacement" graft.

The previous work on cultures of corneal tissue has shown that the cells of the corneal stroma have the ability to divide and migrate.[1] With this in mind, it was felt that if a corneal graft were a "true" graft then donor cornea the cells of which had been "activated" by growth in tissue culture should heal rapidly in the recipient cornea. Accordingly, pieces of donor cornea were grown in tissue culture for varying lengths of time and then transplanted into the recipient corneas. Instead of rapid healing, all eyes revealed a marked repellent reaction on the part of the recipient cornea to all attempts of the donor cells to grow into the recipient cornea (figs. 1 and 2). The reaction was inflammatory in nature and was evidenced by numerous polymorphonuclear leukocytes, macrophages, fibrocytes and neovascularization of the recipient cornea. This inflammation persisted until the donor cells had died and healing had started from the deeper layers of the cornea; as healing progressed, it appeared to push out or extrude the necrotic remains of the donor material, and the end result was a dense fibrous replacement scar of the cornea.

The next step was to repeat work already reported by other investigators on the transplantation of frozen donor cornea.[2] From the freezing experiments previously mentioned,[1] it was known that a frozen piece of cornea was a devitalized tissue in that no visible cells were left after freezing. It was assumed that if a frozen donor cornea should

The work of Mrs. Hoffman was supported in part by a grant from the American Cancer Society.

1. Hoffman, R. S., and Messier, P. E.: Mechanism of Corneal Wound Healing: I. Cells Involved in Corneal Growth and Repair, Arch Ophth. **42**:140 (Aug.) 1949.

2. Weiss, P., and Taylor, A. C.: Transplantation of Frozen Dried Corneas in the Rat, Anat. Rec. **88**:49, 1944.

heal normally and remain transparent the healing and maintenance of transparency must have been the function of the cells of the recipient cornea. Accordingly, corneal grafts were made with the donor cornea frozen for periods varying from twenty-four hours to four months before transplantation. All these grafts exhibited the same pattern, which consisted of healing of the wound edges and maintenance of

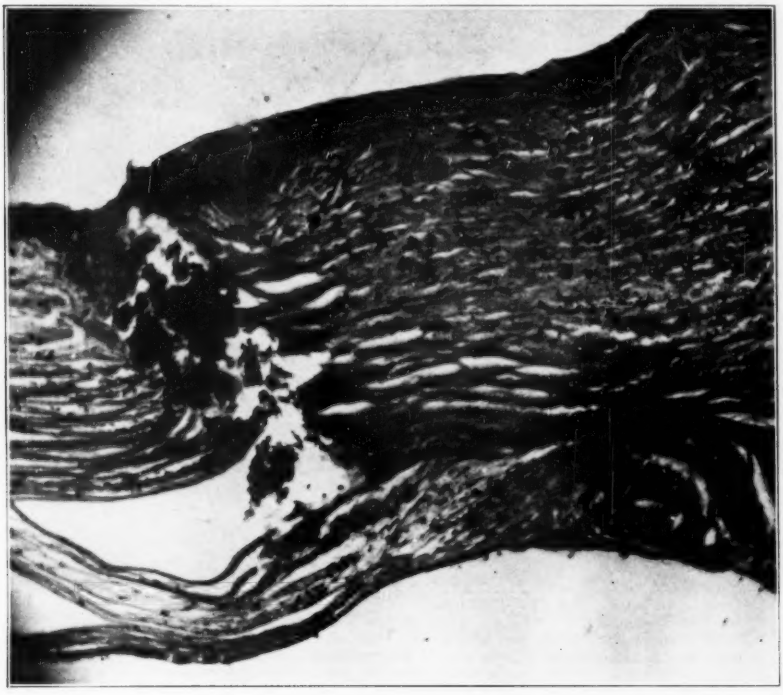

Fig. 1.—Section of cultured donor cornea and recipient cornea six days after transplantation. There is no union of edges, and fibrous growth from the deeper part of the recipient cornea is undermining the donor cornea. In the nonunited areas are accumulations of leukocytes, which form a constant part of this reaction. Hematoxylin-eosin stain; × 100.

transparency, the latter lasting until the tenth to the twelfth day. At this time the center of the graft became cloudy and edematous, and this area either remained opaque or became necrotic and sloughed out, the resultant picture being a dense fibrous replacement scar.

FREEZING EXPERIMENTS

With the carbon dioxide applicator previously described, a 5 mm. square in the center of the living cornea was frozen for one minute. This area thawed out within thirty seconds. Minimal edema of the superficial layers of the area developed and lasted for about forty-eight hours, at which time transparency and complete healing of the area had been effected by the cells migrating from the intact portion of the cornea into the devitalized area.

However, when these frozen areas in the cornea were surrounded by cuts of varying depth, different results were obtained. When the surrounding cuts were shallow, there developed in the enclosed area a mod-

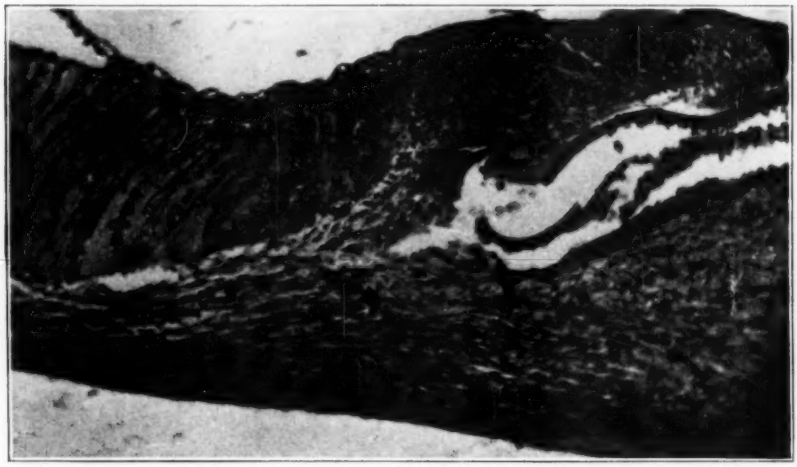

Fig. 2.—Section of cultured donor cornea and recipient cornea fourteen days after transplantation. There is still no union between the two pieces of tissue, and the growth from the deeper part of the recipient cornea has completely undermined the donor cornea, this process continuing until the donor cornea is extruded entirely from the recipient cornea. Hematoxylin-eosin stain; × 100.

erate amount of edema, which lasted three days and then cleared, with complete healing of the cuts at the end of five days (fig. 3 *A* and *B*). When the cuts were deep, the result was the same as with the frozen donor material; i. e., the area became cloudy and either remained opaque or became necrotic and sloughed out (fig. 3 *C* and *D*). When the cuts were deep but did not completely join each other, moderate edema of the frozen area developed, but clearing began at the point where the cuts were incomplete and from this point spread to involve the whole area.

Microscopic examination of these eyes showed that when the cuts in the cornea were deep the frozen cornea beneath the level of the cuts was rapidly repopulated by cells migrating from the surrounding, normal, cornea. However, the frozen area above the level of the corneal cuts received none of these migrating cells because the course of these cells was restricted to the plane of the lamellar structure in which they entered. Instead, the frozen area above the level of the cuts

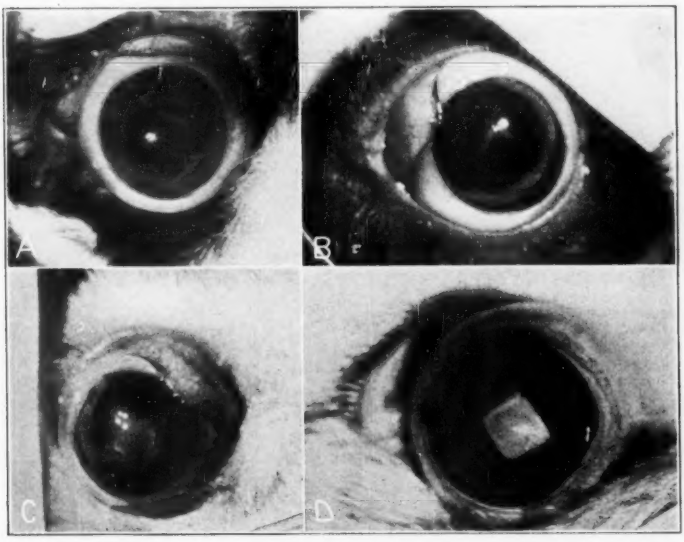

Fig. 3.—*A*, rabbit cornea three days after freezing of a 5 mm. square surrounded by connecting shallow cuts in the cornea. Within the area outlined by the shallow cuts the cornea is moderately edematous and hazy.

B, rabbit cornea five days after freezing of a 5 mm. square surrounded by connecting shallow cuts in the cornea. The cells from the normal cornea have now passed the barrier of shallow cuts and have entered the devitalized area; parallel with the entrance of these cells is the return of transparency to the area. The cuts in the cornea are healed by the invading cells, which are arranged in typical scar fashion.

C, rabbit cornea eight days after freezing of a 5 mm. square surrounded by connecting deep cuts in the cornea. Within the area outlined by the deep cuts the cornea is highly edematous and hazy and the edges are beginning to slough. The cells from the normal cornea have been prevented by the deep cuts in the cornea from entering the frozen area, and this devitalized cornea is now undergoing necrosis.

D, rabbit cornea twenty-one days after freezing of a 5 mm. square surrounded by connecting deep cuts in the cornea. The devitalized and necrotic portion of the cornea outlined by the deep cuts has finally been entered by the cells from the normal cornea, but, because this area has undergone necrosis, there is no normal lamellar arrangement to guide these entering cells, and the cells arrange themselves in typical scar formation.

showed only pyknotic nuclear fragments, marked edema and, finally, necrosis and destruction of the lamellar structure (fig. 4). With the destruction of the lamellar structure, cells migrated into the area and arranged themselves in the typical whorling fashion of scar tissue.

Since the healing and maintenance of transparency of the frozen area or frozen graft appeared to be dependent on the rapid passage of the recipient cells across the wound edges, frozen donor material was again grafted into recipient corneas and, after operation, treated vigor-

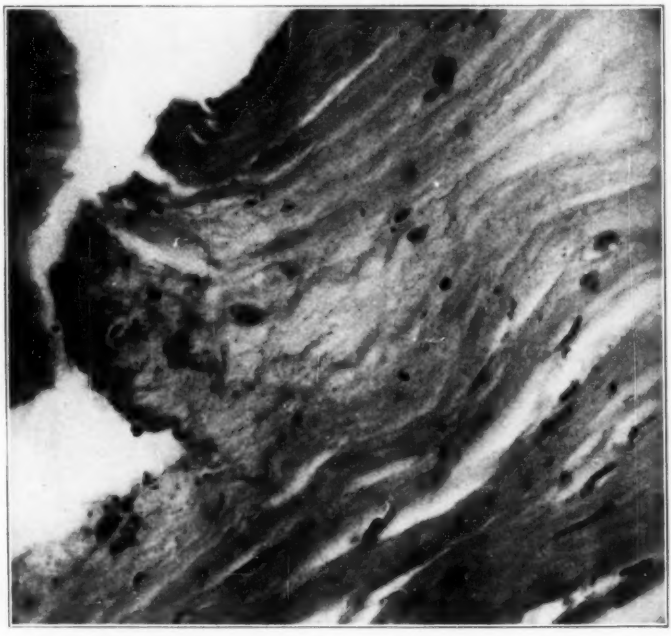

Fig. 4.—Section of a rabbit cornea four days after freezing of a 5 mm. square surrounded by connecting deep cuts in the cornea. That portion of the frozen area which is beneath the level of the cut in the cornea is now repopulated with cells migrating from the normal cornea. The portion of the frozen area which is above the level of the deep cut in the cornea has only pkynotic nuclear fragments, is edematous and shows beginning disintegration of the lamellar structure. With the loss of the lamellar structure in this area, the migrating cells enter and form a typical scar, as shown in figure 3 *D*.

ously with growth extract. However, this procedure appeared to have little effect on the final result, which was necrosis and scarring of the graft.

COMMENT

The results with the tissue culture–grown donor material appear to represent a definite repellent reaction on the part of the recipient cornea to any attempts of the donor cells to grow into the recipient cornea or to have any part in the healing of the wound edges. It is not until all the donor cells have died that any attempts at healing are made, and these appear to be made by the recipient cells; and, in addition to healing, this process appears to expel the dead donor tissue as healing progresses. From this experiment, it would appear that the donor cells have no part in the healing of a corneal graft.

The carbon dioxide–freezing experiments reveal that corneal stroma cells can migrate into a devitalized area and carry on the normal function of stromal cells in this area. However, if the frozen areas are surrounded by deep cuts, or even completely penetrating cuts, as in the case of the frozen grafts, the result is either complete scarring of the area or necrosis and sloughing of the area. It appears that the reason for this failure of the frozen areas to become transparent again was that the cells were unable to cross the wound edges fast enough to take up the normal metabolism of the area, which had been devitalized by the freezing process. The experiments with the deep cuts which did not completely surround the frozen area showed that the frozen area can again become transparent, provided that the cells from the normal cornea can enter the devitalized area quickly to take up the metabolism of this area, even though the path of entrance is limited to a very small bridge of corneal tissue.

SUMMARY

1. Corneal grafts made with donor material grown in tissue culture before operation caused a marked repellent reaction on the part of the recipient cornea to all attempts of the donor cells to grow into the recipient cornea.

2. Corneal grafts performed with donor material frozen before operation resulted in healing of the edges but with necrosis and scarring of the center of the graft.

3. Freezing experiments showed that stromal cells from the normal cornea can migrate into a devitalized area and take up the normal metabolism of this area, provided that entrance of these cells into the area is not delayed too long in passage across the wound edges.

4. The application of growth extract after operation to grafts made with frozen donor material did not sufficiently hasten the passage of the recipient fibrocytes across the wound edges, and necrosis and scarring resulted before healing had been accomplished.

CONCLUSIONS

It would appear that the cells in the donor cornea have no part in the healing of a corneal graft; rather, healing is the function of the cells of the recipient cornea. The maintenance of transparency of the graft appears to depend on the rapid passage of the recipient cells into the donor tissue when devitalized donor material is used. With the use of donor material at present limited to fresh material, it appears that the viable cells in the fresh donor material are capable of carrying on metabolism in the donor tissue until they are replaced by the cells of the recipient cornea. On the basis of the foregoing information, it is felt that a corneal graft should be classified as a replacement type graft.

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CIRCULAR CORNEAL TRANSPLANTS

Surgical Technic; Instruments and Sutures; Comparison with the Use of Square Transplants

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MOST OF the early investigators of corneal transplantation used circular corneal grafts. Von Hippel[1] introduced a corneal trephine and fathered a style of keratoplasty. Elschnig[2] and Filatov[3] adopted von Hippel's general technic and added modifications of their own invention. Thomas,[4] who introduced corneal transplantation to England, used square corneal grafts in his early experiments on rabbits, but later abandoned this procedure in favor of the circular type. Thomas described a tendency of the corners of the square graft to protrude, and even become detached; he also found that one of the loops of the suture frequently came to lie in the incision, thus preventing proper union of the wound. Castroviejo likewise introduced corneal transplantation to the United States. Working at the Mayo Clinic in 1931, he[5] initially performed corneal transplantations on rabbits, following the technics of Elschnig and Thomas; but these operations were all failures. Then Castroviejo[6] devised his own technic, employing first rectangular and later square grafts, with a gratifying percentage of successful operations on laboratory animals. Since that time, he has reported[7] many success-

1. von Hippel, A.: Eine neue Methode der Hornhauttransplantation, Arch. f. Ophth. **34**:108-130, 1888.

2. Elschnig, A.: Keratoplasty, Arch. Ophth. **4**:165-173 (Aug.) 1930.

3. Filatov, V. P.: Transplantation of the Cornea, Arch. Ophth. **13**:321-347 (March) 1935.

4. Thomas, J. W. T.: Transplantation of the Cornea: A Preliminary Report on a Series of Experiments on Rabbits, Together with a Demonstration of Four Rabbits with Clear Corneal Grafts, Tr. Ophth. Soc. U. Kingdom **50**:127-141, 1930; Successful Grafting of the Cornea in Rabbits, Lancet **1**:335-341, 1931.

5. Castroviejo, R.: Preliminary Report of a New Method of Corneal Transplant, Proc. Staff Meet., Mayo Clin. **6**:417-418, 1931.

6. Castroviejo, R.: New Method of Corneal Transplantation: Final Report, Proc. Staff Meet., Mayo Clin. **6**:669, 1931; Keratoplasty: An Historical and Experimental Study, Including a New Method, Am. J. Ophth. **15**:825-838 and 905-916, 1932.

7. Castroviejo, R.: (*a*) Keratoplasty: III. Report of Seven Cases, Am. J. Ophth. **17**:932-945, 1934; (*b*) Queratoplastia: estudo clínico de catorce casos; la córnea de feto como material de transplante, Arch. de oftal. hispano.-am. **35**:404-434, 1935; (*c*) Keratoplasty: Report of Cases, with Special Reference to Compli-

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ful operations on patients and has remained a staunch advocate of the use of square corneal transplants.

Studying at the same institution where Castroviejo conducted much of his research and performed many corneal transplantations, it was natural that I should first employ the square type of corneal graft. The surgical technic of this procedure was discussed in a previous communication [8] (with Dr. J. A. C. Wadsworth). However, regardless of the number of operations performed, transplantation of the square corneal graft remained a difficult procedure, with uncertain results. Strangely, the greatest difficulty with this type of keratoplasty was found in obtaining a square graft and a square window to receive it. It is not simple to apply two straight-cutting blades to a curved surface like the cornea and make two identical, superficial incisions at the same time. It is even more difficult to make the second pair of lines at exact right angles to the first; if this is not done, the resulting figure is not square. After the green mark is made and the anterior chamber incised with the keratome, completion of the incision with scissors is not easy, and cutting the square corners is particularly intricate. When the operation is finished, the corners of the graft exhibit a decided tendency to bulge forward unless the suture passes exactly over the apex of each corner. Because of these difficulties, circular corneal transplants have been tried and now appear to possess certain definite advantages over the square type. The purpose of this paper is to describe the technic of transplantation of circular corneal grafts and to compare this operation with that using the square graft.

TECHNIC OF TRANSPLANTATION

Equipment Required for the Operation.—The instruments employed in securing the circular type of corneal transplant are less complicated than those used in the square type. A corneal trephine and a pair of curved corneal scissors take the place of the double-bladed knife, the special keratome and the straight corneal scissors. The following instruments are recommended (fig. 1): (1) Elschnig's fixation forceps, for immobilizing the eye; (2) a 4.5, 5.5 or 6.5 mm. corneal trephine, for marking out the window in the recipient eye and for making the

cated Ones, J. M. Soc. New Jersey **32**:80-88, 1935; (*d*) Surgery of the Cornea, Internat. Abstr. Surg. **65**:489-505, 1937; (*e*) Results of Corneal Transplantation, Arch. Ophth. **19**:834-835 (May) 1938; (*f*) Present Status of Keratoplasty, ibid. **22**:114-126 (July) 1939; (*g*) Keratoplasty: Comments on the Technique of Corneal Transplantation: Source and Preservation of Donor's Material; Report of New Instruments, Am. J. Ophth. **24**:1-20 and 139-155, 1941; (*h*) Indications and Contra-Indications for Keratoplasty and Keratectomies, Tr. Am. Ophth. Soc. **43**:324-330, 1945; Am. J. Ophth. **29**:1081-1089, 1946; (*i*) Corneal Transplantation, Am. J. Nursing **46**:31-34, 1946.

8. Stansbury, F. C., and Wadsworth, J. A. C.: Surgical Technique of Corneal Transplantation in Rabbits: A Discussion of the Problems Encountered and Suggestions for Their Solution, Am. J. Ophth. **30**:968-978, 1947.

incision into the anterior chamber in both eyes; (3) a fine needle holder, for placing the sutures; (4) curved, modified de Wecker corneal scissors, for completion of the incision into the anterior chamber; (5) spatula, for transferring the graft from the donor eye to the recipient eye and making small adjustments in the position of the graft; (6) small, straight toothless forceps, and (7) small, curved, toothless forceps, for tying the sutures; (8) a standard eye speculum; (9) suture

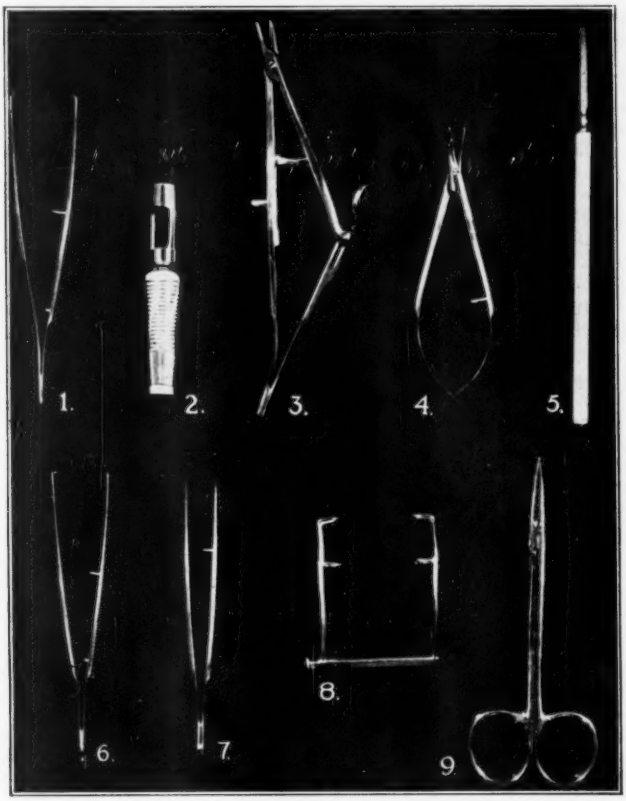

Fig. 1.—Recommended instruments: *1*, Elschnig's fixation forceps; *2*, Elliott type of corneal trephine; *3*, needle holder; *4*, curved, modified de Wecker scissors; *5*, spatula; *6*, small, straight toothless forceps; *7*, small, curved toothless forceps; *8*, speculum, and *9*, suture scissors.

scissors, and (10) two 000000 single-armed, black silk corneal sutures, with atraumatic needles.®

The following preparations are used during the operation: (1) 3.5 per cent iodine solution, and (2) 70 per cent alcohol, for preparing the skin about the

operative field; (3) 4 per cent cocaine solution, for use as drops in the conjunctival sac and for subconjunctival injection; (4) 2 per cent procaine solution, for local anesthesia about the eye, to be injected subcutaneously, and for the retrobulbar injection; (5) 25 per cent solution of mild protein silver, and (6) 1:1000 aqueous solution of epinephrine hydrochloride, for flushing out the conjunctival sac; (7) 2 per cent solution of fluorescein sodium, for staining the superficial corneal incision in the host eye; (8) Ringer's solution, for irrigation; (9) 3 per cent atropine solution, and (10) 1 per cent atropine ointment, to be instilled in the conjunctival sac at the close of the operation.

Preoperative Procedure.—The patient should be admitted to the hospital on the day before corneal transplantation is anticipated. Cultures of material from the conjunctival sac are taken the night before operation. Kodachrome® photographs of the eye are obtained. A final examination of the eye with the slit lamp is worth while to the surgeon. The condition of the recipient cornea, such as thickness or thinness, edema, vascularization, location and depth of scars and presence or absence of anterior synechias should be carefully ascertained. In a case of keratoconus, the location of the apex of the conus and the condition of the surrounding cornea are particularly important. The size and location of the transplant should be decided at the examination with the slit lamp. The reactivity of the pupil and the presence or absence of posterior synechias are noted. The general behavior of the patient is studied; an apprehensive patient is a poor subject for corneal transplantation, particularly when local anesthesia is used. If the patient falls into this category, or if the patient is a child, general anesthesia is indicated.

A cathartic is administered the night before operation, and a soapsuds enema is given the next morning. If the operation is to be in the afternoon, a fluid lunch is prescribed; if in the morning, breakfast is omitted. Two hours before operation, 0.2 Gm. of pentobarbital sodium U. S. P. is given and, one hour before operation, another 0.1 Gm. of the same drug is administered. The pupil of the eye to be operated in is dilated with 10 per cent phenylephrine hydrochloride (neo-synephrine hydrochloride®) and 5 per cent hemotropine hydrobromide, 1 drop of each drug every fifteen minutes, beginning two hours before operation, and kept dilated with these drugs until the patient goes to the operating room.

Surgical Procedure.—The skin about the eye to be operated on is scrubbed with 3.5 per cent solution of iodine, and then with 70 per cent alcohol. A 4 per cent solution of cocaine is instilled into the conjunctival sac. The operative field is draped with sterile towels. Local anesthesia, employing 2 per cent solution of procaine, is given by subcutaneous injection into the periorbital region. A retrobulbar injection of 1.5 cc. of 2 per cent procaine solution is given, and a small amount of 4 per cent cocaine solution is injected subconjunctivally, in the upper and lower fornices. The conjunctival sac is filled with 25 per cent solution of mild protein silver U. S. P. and washed out with 1:1,000 solution of epinephrine hydrochloride. A speculum is inserted between the lids.

The eye is fixated with Elschnig's fixation forceps, and the corneal circle to be removed is marked out by a superficial incision with the corneal trephine. A drop of 2 per cent solution of fluorescein sodium is dropped on this circle and quickly washed away with Ringer's solution. Using 000000 or 0000000 single-armed, black silk corneal sutures, with atraumatic needles,® one now places two sutures in the corneal stroma about the green circle (figs. 2 and 4). With the first suture, a bite is made in the cornea from 10 to 8 o'clock, so that the buried portion of the suture is about 1 mm. from the fluorescein-stained circle. The same needle is then reintroduced at 2 o'clock and brought out at 4 o'clock. The two ends of

this suture are laid to either side, and the loop from 8 to 2 o'clock is placed either above or below the window to be excised. With the other suture, a bite is made from 1 to 11 o'clock, and another, from 5 to 7 o'clock. The ends of this suture are likewise extended above and below the cornea, respectively, and the loop formed placed to either side of the window to be excised. In placing these corneal sutures, care is taken to insure that the intracorneal portions (at 12, 3, 6 and 9 o'clock) are at least 1 mm., and preferably not more than 1.5 mm., from the green circle. It is essential to place these intracorneal bites symmetrically about the circle, so that all four segments within the corneal stroma are of the same length and so that the opposing intracorneal segments are parallel and directly opposite each other. If this is done, the suture when tied will divide the corneal circle into eight equal parts (like the pieces of a pie). One of the suture ends with a needle is then severed, and a Moss suture is placed in the corneal stroma in the center of the circle; this is loosely tied and the ends are cut 1 or 2 mm. from the knot.

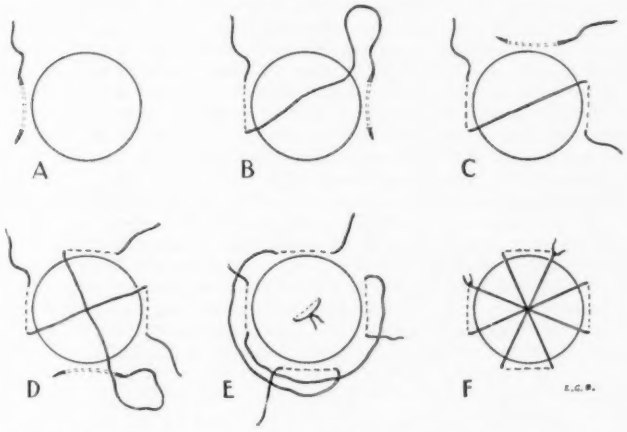

Fig. 2.—Diagram illustrating the steps in placing the two sutures in the cornea. *A* and *B* show the insertion of the first suture, and *C* and *D*, the insertion of the second suture. *E* shows the loops removed from the incision and the Moss suture; *F*, the completed suture pattern.

The donor eye is then held in a piece of gauze bandage, and a trephine incision is made through the center of the cornea into the anterior chamber. An attempt is made to hold the trephine "normal" to the cornea, in order that the incision into the anterior chamber may be as large as possible. Seldom, however, is the resulting incision through Descemet's membrane larger than one-third the circumference of the circle. One completes the remainder of this incision with the curved corneal scissors, avoiding any manipulation of the round disk which is being excised. No attempt is made to cut the incision on a bevel, either in the donor eye or in the host's cornea. Careful observation of the incision will disclose that the circle on the endothelial side of the cornea is always slightly smaller than the one on the epithelial aspect, without any conscious attempt to make a bevel. The graft is removed from the donor eye with a spatula and placed in a beaker of Ringer's

solution; it is washed about in this solution to remove any fragments of iris pigment clinging to its posterior surface.

The recipient eye is again fixated with Elschnig forceps, and the position of the sutures is checked, to make sure that they are free from the incision. The corneal trephine is then reapplied to the green circle in the epithelium, and the incision is carried down into the anterior chamber. As soon as the iris is seen to move, the trephine is removed. The portion of cornea to be excised is lifted slightly above the lens by traction on the Moss suture, and incision of the rest of the circle is completed with the fine, curved corneal scissors. The curvature of the circle is most accurately followed by employing a number of short bites with the scissors, rather than a few long ones. After the incision is completed and the window formed, the donor graft is removed from the Ringer solution with the spatula and placed in the window in the recipient cornea. The excised corneal disk from the host's eye is sent to the pathologic laboratory for examination. The sutures are then tied with the pair of small toothless forceps. One of the loops is picked up in the curve of the curved forceps, and either end of this suture is pulled with the other forceps until the loop lies in its proper place across the graft. The remaining loop is then picked up and drawn into position in the same manner. If the horizontal suture is to be tied first, the two ends are brought together, either at 10 or 4 o'clock, depending on the convenience of either site, and tied. Likewise, the vertical suture may be tied either at 1 or at 7 o'clock. Either one of the sutures may be tightened first, and either one may be tied first. Care is exercised to tie the sutures as close to the bite in the cornea as possible, so that the knot will not lie over the incision. The tied sutures should not be taut over the graft.

The position of the graft is then adjusted with the spatula, as good an approximation of the wound edges as possible being secured. Air may be injected into the anterior chamber at this time, in the same manner as after cataract extraction. Ordinarily, this is not necessary, as the anterior chamber will begin to reform before the end of the operation; it is a useful maneuver, however, when there is any particular reason to fear anterior synechias. A 3 per cent solution of atropine is instilled into the conjunctival sac. The speculum is removed and an ointment containing 1 per cent atropine sulfate instilled into the conjunctival sac. The lids are closed, and a binocular bandage is applied. A fiber mask is tied around the patient's head for protection, and he is taken back to his bed.

Postoperative Care.—Absolute bed rest is prescribed for the first nine days. Codeine and acetylsalicylic acid are given for relief of pain in the eye. One of the barbiturates is usually given two or three times a day during this period; every attempt is made to keep the patient as quiet as possible. A light diet is given, and bowel movements are not encouraged for at least six days. Visitors are also discouraged if possible. On the third postoperative day, the dressing is changed and the position of the graft and sutures is determined. The graft is hazy and swollen at this time, from imbibition of fluid through the incision and from the pressure of the sutures. The pupil, if mobile at the time of operation, is now small; 10 per cent phenylephrine hydrochloride (neo-synephrine hydrochloride®) and 5 per cent homatropine hydrobromide are instilled into the conjunctival sac, to prevent it from becoming fixed. If there is no obvious tendency for the graft to protrude, and the anterior chamber is satisfactorily reformed, the same loose binocular bandage is reapplied. However, if the graft bulges more than can be explained by simple corneal edema, a firm adhesive bandage is applied.

On the sixth postoperative day, the eye is again dressed, and the corneal sutures are removed. Several drops of a 4 per cent solution of cocaine are instilled into the conjunctival sac. If the patient is a child or a particularly uncooperative adult,

general anesthesia is employed for removal of the sutures; chloroform is a good anesthetic for this short procedure. The upper lid is elevated and the patient asked to look down toward his feet while one arm of each suture is cut. The scissors are held with the points directed toward the top of the patient's head, so that an involuntary upward movement on his part can only cause the suture to slip off the tip of the scissors blade. The knot of each suture is then grasped with the small toothless forceps and the sutures are removed. A mild pressure bandage is then applied to the eye operated on, using long strips of adhesive tape that have been "flamed" to insure their sticking to the skin. The skin on that side of the face is first painted with tincture of benzoin U. S. P., which protects the skin and makes the adhesive tape adhere better. A cathartic is given on the sixth night, followed, if necessary, by an enema the next morning.

The bandage is subsequently changed every third day, pressure on the eye being increased with each dressing. The intact eye is left open on the third dressing and the patient allowed to sit up in bed. After the fourth dressing, he is allowed to sit in a chair beside the bed. The pupil is dilated during each dressing. After the fifth dressing, the patient is allowed bathroom privileges and may walk about. The pressure dressings are continued as long as there is any tendency of the graft to bulge; this is determined by examination with the slit lamp after the bandage is left off for an hour or two. The pressure dressings are maintained for at least three weeks, and often five or six weeks in case of keratoconus. The patient is usually allowed to go home after three weeks, even though the pressure dressing is still used. The visual acuity may be casually tested after three weeks, but refraction is not worth while for approximately two months.

COMMENT

Corneal Trephines.—A considerable amount of the research on corneal transplantation has been devoted to the development of corneal trephines. The goal has been the production of a trephine that would cut the entire incision into the anterior chamber in one operation. This problem has been approached in three general ways: (1) by increasing the speed of the incision, by means of mechanical trephines; (2) employing a trephine with a "guard," to hold the incised cornea in position and avoid loss of the anterior chamber until after completion of the incision, and (3) by "punching out" the entire corneal disk, in the manner of a paper punch. Illustrative of the last method is the "punch" devised and advocated by Wiener and Alvis.[9] The use of this type of instrument necessitates an additional incision into the anterior chamber for insertion of the lower arm of the punch; for this reason, the "punch" type of corneal trephine has never enjoyed wide use.

Mechanical Trephines: A number of mechanical trephines have been devised: first, trephines driven by a spring mechanism incorporated into the handle of the instrument (von Hippel,[1] Elschnig[2] and Filatov[3]), and, more recently, those driven by electricity. Representative of the first type is the Green trephine; this is an enlarged form of the

9. Wiener, M., and Alvis, B. Y.: Transplantation of Cornea by Means of a Mechanically Obtained Beveled-Edged Segment, Am. J. Ophth. **23**:877-881, 1940.

earlier Green trephine used in operations for glaucoma. Green [10] claimed that this instrument will cut the entire circular incision into the anterior chamber at one time and did not mention the use of scissors in his operative procedure. Katzin [11] has recently endorsed this trephine, stating that over 90 per cent of 300 grafts were cut completely with the trephine alone. The most modern of the mechanical trephines is electrical; a circular blade is inserted into the hand piece of a dental drill (fig. 3). The remainder of the apparatus consists of a table dental power setup, with a foot control. In my experience, complete incision of the cornea with the electric trephine can seldom be performed. It is true that a larger portion of the circular incision can be carried down into the anterior chamber than is usually accomplished with the manual trephine. Against this small advantage, however, are the disadvantages of (1) an unwieldly and more complicated apparatus, (2) increased danger of injury to the lens and (3) the obvious need for frequent practice by the occasional operator.

It appears that the advocates of the mechanical trephines have overlooked one factor. In addition to the speed of rotation of the trephine, for which advantage they endorse the electrical and spring-driven instruments, the "normal" position of the trephine in relation to the cornea is of great importance in attempting a complete incision. Indeed, it is impossible to make a complete incision with any instrument unless it is held very close to a 90 degree angle with the apex of the cornea, and this is difficult to accomplish. The necessary increase in bulk and weight of the mechanical trephines make this optimal position only more difficult to attain.

Trephine with a Guard: Representative of the second group of trephines is the Paton type, which is a hand instrument with an encircling collar that can be fixed at varying distances above the cutting edge. Paton [12] stated that the graft can be completely excised with this trephine, eliminating the use of scissors. Contrary to his experience has been that of Franceschetti,[13] who admits that he is unable to cut a complete graft, even though he employs the superlative Franceschetti trephine made by Grieshaber.

The adjustable collar, or guard, was added to the corneal trephine with the idea that it would hold the cut edges of the incision together,

10. Green, M. I.: A Simple Technic for Corneal Transplantation, Arch. Ophth. **33**:150-152 (Feb.) 1945.

11. Katzin, H. M.: Contributions to the Technic of Corneal Grafting, Arch. Ophth. **37**:379-382 (March) 1947.

12. Paton, R. T.: Complications Encountered in Keratoplasty, read before the New England Ophthalmological Society, Jan. 15, 1947, Am. J. Ophth. **30**:1436-1439, 1947.

13. Franceschetti, S., in Foster, J.: An Oculist in Switzerland, Brit. J. Ophth. **32**:83-111, 1948.

avoiding loss of the anterior chamber until the entire periphery of the graft was incised. By the same mechanism, the collar is supposed to prevent too deep penetration of the anterior chamber and consequent injury to the lens. In practice, however, the aqueous escapes as soon as any portion of the incision opens into the anterior chamber, with

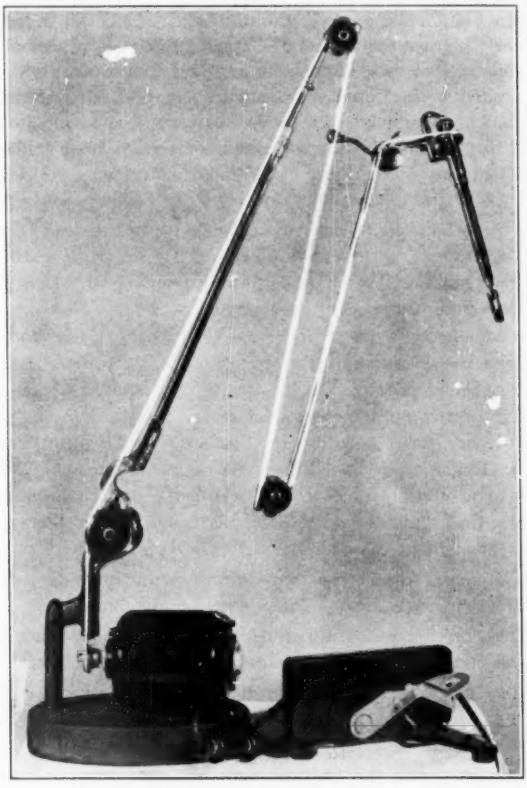

Fig. 3—Photograph of the electric corneal trephine.

this instrument just as with any other. The guard does not prevent the loss of aqueous through the outer edge of the incision; moreover, there is nothing to prevent loss of fluid from the inner side of the incision (into the trephine). Further, the guard does not prevent injury to the lens; when the anterior chamber is lost, the lens will come up against this trephine blade, as well as against any other.

Manual Trephine: In contradistinction to these three types of corneal trephines is the simple Elliott type of manual trephine (fig. 1, *2*), which is twirled between the thumb and the fingers, just as in operations for glaucoma. This type of instrument has been used and recommended by Thomas,[14] Castroviejo [7g] and others. This trephine is practical, both for marking the cornea and for making the incision. The instrument is light and easily held in the hand; the cutting edge is visible at all times. It is more likely to be applied to the cornea in a "normal" position because of these factors. It can be removed during the incision and reapplied in the same spot without any difficulty. Further, it is an instrument of simple pattern, easy to clean and to maintain. Considering that the much desired complete incision is not likely to be attained with any of the more complicated instruments yet devised, the simplicity of the manual trephine warrants its further employment.

Sutures.—The single continuous suture advocated by Castroviejo is an excellent one, in that it has loops of suture crossing the incision every 45 degrees of its circumference, producing the same effect as would four single sutures. However, it has the manifest disadvantage of being complicated; the several loops of this suture tend to get in the way during the operation and are often difficult to untangle at the end of the surgical procedure. In an attempt to simplify this aspect of the operation, the two sutures described under "Surgical Procedure" were tried, and they proved eminently satisfactory. Thomas [14] used these sutures in England and called them "criss-cross" sutures. Considering the number of investigations in this field in the past one hundred years, it is likely that some one may have used such a simple scheme before Thomas (at any rate, he makes no claim of priority for them).

Comparison of the "criss-cross" sutures with the single, continuous suture of Castroviejo reveals the following advantages:

1. The "criss-cross" sutures necessitate only four bites into the cornea, as compared with five bites for the continuous suture.

2. They offer less interference during the operation. Figure 4 is an artist's drawing of the location of these two sutures during the surgical procedure.

3. They are easier to draw up and tie. There are only two loops of suture with this method, and either one can be tightened at either end, and likewise tied at either end of the suture.

4. They are easier to remove after operation. It is necessary only to cut each suture once (at any place) and the entire suture can be removed in one piece, by traction on the knot.

14. Thomas, J. W. T.: The Technique of Corneal Transplantation as Applied in a Series of Cases, Tr. Ophth. Soc. U. Kingdom **55**:373-392, 1935.

5. They are as effective as the single, continuous suture. There are eight loops of suture crossing the incision, 45 degrees apart, just as in the single, continuous suture. Viewed from a functional point of view, the two methods of suture hold the graft in place by identical means.

The principal advantage claimed for the single, continuous suture is that one can distribute the tension evenly throughout the suture by lifting under the central crossing point of the loops with a spatula at the end of the operation. This has not proved true in my experience. Considerable resistance is encountered when a suture is pulled through the corneal stroma by traction applied at right angles to the intracorneal segment. This resistance increases as the angle of trac-

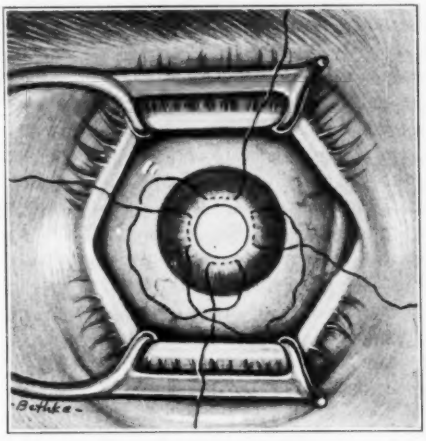

Fig. 4.—Artist's drawing showing the two corneal sutures as they appear during the surgical procedure.

tion becomes more acute, so that, at a 45 degree angle, the suture will cut through the cornea rather than slide through the corneal canal. Those who advocate this procedure are suggesting that they can overcome this resistance at four 90 degree angles and at four 45 degree angles, simultaneously, with only the force of a gently lifted spatula. Simple experiments will demonstrate that this is impossible:

1. Take an enucleated globe and make a round or square mark in the epithelium, as in corneal transplantation. Place the first corneal bite from 9 to 7 o'clock, as in the single, continuous suture, and attempt to draw the suture through the cornea by pulling at a 90 degree angle to the intracorneal segment of the suture. A surprising amount of

force is required. Then try to draw the suture through the cornea with traction at 45 degrees to the intracorneal segment; this is more difficult, and the force required will usually cause the suture to cut through the cornea.

2. Then place the second bite in the cornea from 1 to 12 o'clock, as in a keratoplasty, and attempt to pull the suture through the two corneal canals at the same time, by traction toward 6 o'clock (the normal direction of pull of this loop). It is impossible to do so. At this point, one is trying to draw the suture only through one 90 degree and two 45 degree turns. Placing the remaining three corneal bites (as in the completed single suture) will only add to the difficulty. Careful study of the Castroviejo suture will show that this resistance would have to be overcome both at all four 90 degree turns and at all four 45 degree turns, at the same time, for the proposed redistribution of tension to occur.

There is also clinical confirmation of these statements for those who are acquainted with the single, continuous suture. Those who have employed this suture will remember occasions on which at postoperative dressings one or more loops of the suture have been found loose and the others normally taut. Some will also remember instances in which one loop has cut through the cornea and lies free in the conjunctival sac, while the rest of the suture lies in its expected position. These findings can be explained only by the admission that a suture does not readily slide through the corneal stroma.

With any corneal suture involving sharp angles, therefore, it would appear more feasible to adjust the tension in the suture to the desired amount at the time of tying. After the suture is tied, tension can be effectively redistributed only by means of forceps at both ends of a buried segment and exertion of traction in one direction or the other.

Additional Sutures.—Occasionally, the final suture pattern will be asymmetric and the graft will bulge at some point. If the bulging is slight, it is better not to interfere. The sutures are not the only factor holding the graft in place; the pressure of the lids and of the bandage is of equal, or even greater, importance. However, if the bulge is alarming, it may be impossible to resist placing an additional suture. Direct coaptation of the wound edges with a suture at the site of the bulge is possible surgically, but this procedure is always unsuccessful because the suture subsequently pulls the graft toward the extra suture and causes a dehiscence in the wound directly opposite. A suture extending across the whole cornea, from limbus to limbus, so that it passes over the bulge and compresses it, has been found more successful.

Evaluation of the Circular and Square Types of Corneal Grafts.—Castroviejo [78] cited seven advantages of the square graft as compared

with the round transplant: (1) It is easier to bevel the graft and the cornea of the host; (2) the wound edges made by a trephine are irregular, and those made by a trephine-scissors combination are still more irregular; (3) completion of the round incision with scissors becomes progressively more difficult as the diameter of the circle diminishes; (4) the blades of the double-bladed knife are more easily tested and replaced than those of trephines; (5) the double-bladed knife offers more flexibility than does the trephine; (6) for grafts of different sizes, trephines of different diameters are needed, while the double-bladed knife is adjustable for all sizes of grafts, and (7) the latter instrument can be used to outline several grafts from the same donor eye (one, two, three or four square grafts from one cornea).

In refutation of these arguments, the following facts are offered, in the corresponding order:

1. Beveling of the graft or of the window in the host eye is not necessary, because the contraction of Descemet's membrane provides an automatic bevel in the graft, and because it is impossible to cut out the window in the recipient eye without a slight bevel posteriorly.

2. It is difficult to see why a straight knife should cut a cleaner incision than a curved one, provided that the instruments are equally sharp. The usual trephine incision in the cornea is sharp and symmetric. In regard to trephine-scissors combinations, it should be pointed out that the trephine cuts nearly the entire incision through the corneal stroma, leaving only a few corneal fibers, together with Descemet's membrane and the endothelium, to be severed with the scissors. On the other hand, the incision made by the double-bladed knife is only superficial; it cannot be carried deep into the cornea and still remain within the boundaries of the square. Therefore, most of the incision in making the square type of transplant must be made with scissors. It is incredible that a cleaner incision can be made by the crushing action of scissors than by the cutting action of a trephine.

3. It is true that the circular incision becomes more difficult as the circle becomes smaller, but it is equally true that the square incision increases in difficulty with smaller squares.

4. It is difficult to understand how the double-bladed knife can be tested in the same manner as a cataract knife. It is granted that the blades of the double-bladed knife are cheaper to replace than a trephine blade, but it is easier to change the blade of a trephine than the razor blades of the knife.

5. It is true that the double-bladed knife is more flexible than the trephine; that constitutes one of my main objections to the instrument

6. It is granted that the double-bladed knife is better suited to preparation of different sizes of transplants.

7. It is impossible to concede that three or four square grafts can be cut from the same donor cornea. This would be technically difficult; there would be great differences in thickness in each graft, and, most pertinent of all, the cornea is not large enough.

To me, the circular type of corneal transplant appears more desirable than the square type; the following factors serve as the basis for this opinion:

1. Marking the cornea is easier with a trephine than with the double-bladed knife. A perfect circle can be expected with the corneal trephine, while a perfect square is difficult to obtain with the double-bladed knife. The razor blades in the double-bladed knife are flexible and tend to separate when applied to the cornea; thus the resulting pair of incisions may not be parallel. Often the second pair of lines is not made exactly at right angles to the first pair, and a parallelogram instead of a square is the result; moreover, the chances of cutting an identical parallelogram in the other eye are not very great. Further, with the double-bladed knife, it is possible to cut too deep at some point in the square (it is impossible to cut a straight incision with a constant depth in the curved cornea), allowing the cornea to bulge at this weakened focus and become distorted; or one blade of the knife may miss the cornea entirely at some point, leaving a defect in the fluorescein-stained figure. It is difficult to reapply the double-bladed knife in this instance.

2. Placing the sutures is a little more difficult in the circular type of operation. The corners serve as points of reference in the square operation, and the surgeon has only to estimate the halfway points between the corners. Symmetric location of the sutures in the circular operation may be attained with practice, however, and exact symmetry is not so important in this type of transplantation, where there are no corners to hold down.

3. Completion of the incision with scissors is easier with the circular operation, where there is only one incision, with one beginning and one ending. With the square form of keratoplasty, there are four separate incisions to make with scissors and four difficult corners to cut out. At each corner of the square transplant, there are two borders to the incision: one parallel to the cornea, and one at right angles to the corneal surface. The latter is the one that causes trouble; if one "overcuts" the corner in order to carry a true square down through Descemet's membrane, he may cut the suture (which is only 1 mm. away). The depth of corneal tissue to be severed with scissors in the circular operation is very slight, but in the square type of keratoplasty most of the thickness of the cornea is cut with scissors (particularly at the corners).

4. A better fit of the graft into the window in the host's cornea is obtained with a circular transplant because of factors 1 and 3. Mainly because it is possible to mark out two identical circles with the trephine, but also because the incisions can be more accurately completed with scissors, the circular graft will usually fit better than the square type.

5. Less astigmatism is found after operation with the circular form of transplantation. This can probably be attributed to the tendency of the corners of square transplants to bulge.

6. A better cosmetic result is generally conceded to the circular type of operation, where a thin scar may be almost imperceptible against the normal markings of the iris. This factor is not nearly so important, however, as factor 5.

CONCLUSIONS

1. A simplified, surgical procedure for use of circular, penetrating corneal transplants is described.

2. Various types of corneal trephines are discussed and evaluated. The simple, manual, Elliott type of instrument is recommended.

3. A simple method of suturing the graft in place is presented and is compared with the single, continuous suture formerly used.

4. The addition of extra corneal sutures in case of a bulging graft is briefly mentioned.

5. The circular type of corneal transplant is compared with the square type. The conclusion is reached that the circular graft is technically easier to accomplish and that the results with it are visually and cosmetically better.

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ATROPHY OF THE OPTIC NERVE IN TABES AND DEMENTIA PARALYTICA

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THE PROBLEMS of atrophy of the optic nerve in syphilitic diseases have received new stimulation through the valuable work of Bruetsch.[1] Since I am one of the few investigators in this field who has had the opportunity to examine a rather large anatomic material, I should like to discuss some of these problems.

INCIDENCE OF ATROPHY OF THE OPTIC NERVE IN TABES AND DEMENTIA PARALYTICA

On the basis of the ophthalmoscopic picture alone, according to various statistics, optic nerve atrophy exists in 5 to 10 per cent of cases of dementia paralytica and in 15 to 20 per cent of cases of tabes. The figures are entirely different if one counts the cases in which anatomic examination shows a typical degeneration of the peripheral optic pathways and the cases in which the degenerative process is still in an early stage. I found degeneration of the visual pathways in 16 of 53 cases of dementia paralytica, in all of 5 cases of the tabetic form of dementia paralytica and in 11 of 27 cases of tabes, an incidence about twice that in the clinically detected cases.

The percentage in Stargardt's [2] studies was even higher. In 8 of his 24 cases of dementia paralytica (examination was made only in very few cases of the tabetic form of the disease and of tabes) the visual pathways were normal, and in all the others there was some degree of degeneration.

Bruetsch's [1] observations were similar, and he expressed his belief that the discrepancy between clinical and anatomic findings is due to the fact that in the era before the advent of malaria therapy dementia paralytica, in contrast to tabes, was a fatal disease within an average of one to three years. Furthermore, the patient with dementia paralytica is often not able to recognize his visual failure; and, certainly, in large hospitals for mental disease examination by an ophthalmologist was

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1. Bruetsch, W. L.: Malaria Therapy in Syphilitic Primary Optic Atrophy, J. A. M. A. **130**:14 (Jan. 5) 1946; Tr. Am. Neurol. A. **72**:129, 1946; Unilateral Syphilitic Primary Optic Atrophy, Arch. Ophth. **39**:80 (Jan.) 1948.

2. Stargardt, K.: Arch. f. Psychiat. **51**:711, 1913.

not made often. A third, and most interesting, point is that even in the presence of dementia paralytica and tabes the disk may look normal despite a certain degree of degeneration throughout the optic nerve (cases 14, 15, 16, 17, 21 and 22 of Stargardt [2]). This is contrary to the former belief that the ophthalmoscopic aspect of a pale disk is always the earliest symptom of optic nerve atrophy in tabes. There is no doubt, however, that pallor of the disk may be present even though the patient is not aware of visual failure.

PATHOGENESIS OF PRIMARY ATROPHY OF THE OPTIC NERVE IN TABES AND DEMENTIA PARALYTICA

Although the clinical entities dementia paralytica and tabes in their pure form are very different, the clinical course of optic nerve atrophy

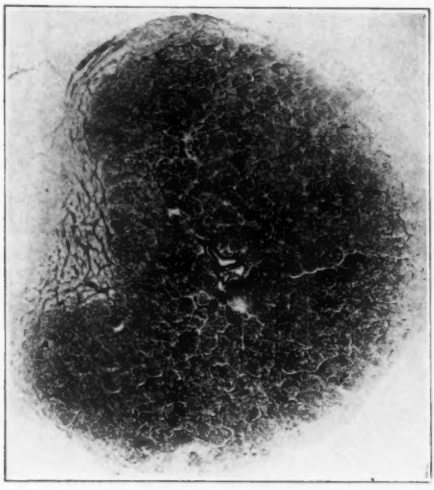

Fig. 1 (case 1).—Retrobulbar part of optic nerve in a case of tabes.

and its resistance to antisyphilitic drugs are similar in the two conditions, and one feels justified in considering the pathogenesis of the degeneration of the optic nerve in these two diseases on the same basis. This is not so with descending optic nerve atrophy in basilar syphilitic meningitis, and it was confusing when Bruetsch [1] proposed using the term primary syphilitic optic nerve atrophy for the degeneration of the optic nerve in all kinds of syphilitic disease of the central nervous system. This simplification is not in accordance with clinical and anatomic facts. In basilar meningitis with involvement of the intracranial portion of the optic nerves or optic chiasm the degeneration of the optic nerve is

"secondary" to an intense inflammatory infiltration, and the pallor of the disk sets in long after the visual disturbances; if the process is not too far advanced, antisyphilitic treatment has a prompt effect.

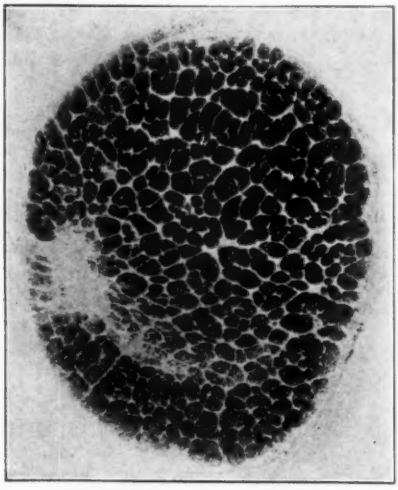

Fig. 2 (case 1).—Retro-orbital part of optic nerve in a case of tabes.

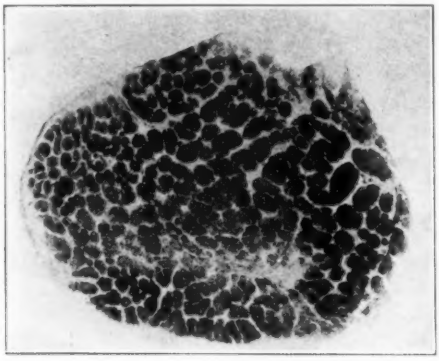

Fig. 3 (case 1).—Intracranial part of optic nerve in a case of tabes.

The pathogenesis of primary optic nerve atrophy in tabes and dementia paralytica is in many ways still a riddle. However, the anatomic investigations have not been in vain, and certain observations cannot be neglected in any attempt to explain the pathogenesis.

(*a*) *Origin of Degeneration at Periphery of Nerve.*—There is general agreement that the degeneration always starts at the periphery, adjacent to the pial sheath; the pathologic agent, therefore, always enters the nerve from the pia.

This being accepted, the following 2 observations are of special interest. As shown in the illustrations, in the case of tabes there was characteristic degeneration of the papillomacular bundle, which was located retrobulbarly at the periphery of the nerve, whereas more posteriorly, especially intracranially, the degeneration was in the center of the nerve (figs. 1, 2 and 3). It is noteworthy that the optic nerve of the other eye did not show degeneration of fibers but that there was about the same, rather pronounced, lymphocyte and plasma cell infiltration in the intracranial portion of the two optic nerves.

In the second observation (a case of dementia paralytica) the degeneration was most pronounced in the retrobulbar portion of the optic nerve and faded away more posteriorly (figs. 4, 5 and 6). Besides this pronounced degeneration there was a second (small) area, separate from the larger one. In the intracranial portion there was moderate infiltration of the optic septums, without any connection with the atrophic area.[3]

These two observations are of importance because they seem to prove that the starting point of the primary optic nerve atrophy may be in the retrobulbar portion of the nerve, and that the assumption of Stargardt,[2] Bruetsch [1] and others, namely, that the process always begins intracranially, does not conform with the facts. I do not wish to deny that in other cases the degeneration may start near the chiasm, but as yet there is no real proof. It is also possible that the process may start in the intracanalicular portion of the nerve. I have even seen localized atrophic changes in this region several times, but I am not sure whether they would have developed into the typical optic nerve atrophy of tabes.

(*b*) *Relation of Degeneration of Optic Nerve Fibers to Cellular Infiltration in Pia and Neighboring Septums.*—Bruetsch took it for granted that the degeneration was caused by inflammatory processes, relying on his own observations, as well as on the authority of Stargardt.[2] Stargardt no doubt was inclined to believe that the degeneration of the optic nerve of tabes and dementia paralytica always starts near the chiasm and that the exudative process plays a great role. But his statements are somewhat controversial. He stated [4] that there is no degeneration of a nerve fiber if there is not somewhere in its course an inflammatory process. Elsewhere,[5] he asserted that exudative and degenerative

3. More details on these cases are given in my monograph (Syphilis und Auge, Berlin, Julius Springer, 1928, p. 370).

4. Stargardt,[2] p. 904.

5. Stargardt,[2] p. 936.

processes are independent of each other but that they have the same source.

In my studies I found degeneration and exudation in some cases and degeneration or exudation alone in others.[6] A most convincing demonstration of how independent of each other these two pathologic reactions can be is presented: Anatomic examination of an optic nerve from a case of dementia paralytica in my collection showed a marginal area passing through the optic nerve and chiasm which could be stained only with osmic acid (Marchi method). This Marchi degeneration is always

Fig. 4 (case 2.)—Retrobulbar part of optic nerve in a case of dementia paralytica.

a sign of a degeneration not older than about two months. This case is probably the earliest instance of an anatomically examined area of primary degeneration which exists in the literature. Throughout the length of this degenerated area there was no evidence of infiltration with lymphocytes or plasma cells! If the inflammation is really the *sine qua non* of the occurrence of degeneration in the optic nerve, it should have been present at such an early stage.

6. Igersheimer, J.: Jahresb. u. d. ges. Ophth. **48**:225, 1924; Deutsche med. Wchnschr. **52**:943, 1926.

Fig. 5 (case 2).—Retro-orbital part of optic nerve in a case of dementia paralytica.

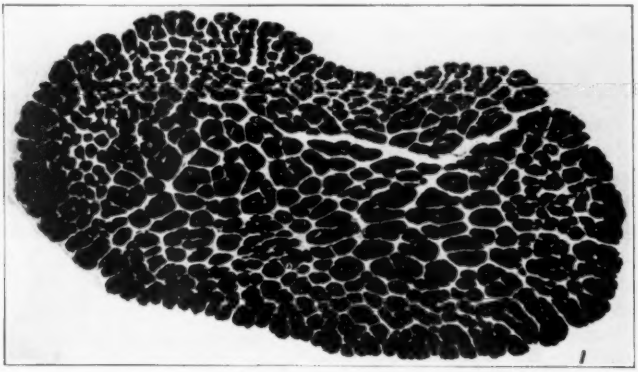

Fig. 6 (case 2).—Intracranial part of optic nerve in a case of dementia paralytica.

Behr [7] made the same observation as I. Even among Stargardt's published cases there were a number in which a marked discrepancy between the occurrence of degeneration and of exudation appeared. Bruetsch saw inflammatory changes in the intracranial portion without degeneration, but apparently not the reverse. How many of his patients had dementia paralytica and how many meningovascular syphilis is not mentioned; a case of pure tabes was apparently not in his material.

(*c*) *Treponemes and Optic Nerve Atrophy.*—I found treponemes in the leptomeninges in 1 case of tabes, in 2 cases of the tabetic form of dementia paralytica and in 7 cases of dementia paralytica. Two points must be stressed: 1. The organisms were located in the arachnoid, the pia and sometimes the marginal septums, but never in the neural parenchyma. 2. They were observed with inflammatory changes and, more frequently, with degenerative signs in the nerve, but never in the normal nerve of a person with tabes or dementia paralytica. It is, of course, regrettable that the number of positive results was not greater, but anyone who has done any staining and searching for spirochetes will understand this.

SUMMARY

In any attempt to explain the pathogenesis of atrophy of the optic nerve in tabes and in dementia paralytica, the following points should be borne in mind:

1. The pathologic process in the optic nerve in these diseases always starts in the marginal zone, near the pial sheath, and therefore the causative agent enters from the meninges.

2. Degeneration has been seen in the earliest stages, without any signs of exudation; on the other hand, degenerative and infiltrative processes exist together, and inflammatory signs in the intracranial portion of the nerve are frequently present without any atrophy.

3. The treponemes in the cases in which they could be found were always located in the arachnoid and pia of the optic nerve, and never in the neural parenchyma.

4. Antisyphilitic drugs, such as arsenicals or bismuth preparations, generally have no healing or arresting effect on the optic nerve atrophy in tabes and dementia paralytica, whereas they may influence descending optic nerve atrophy in basilar meningeal syphilis. Why malarial treatment has better results in primary syphilitic atrophy of the optic nerve is not yet known; certainly, it cannot be explained by its effect in decreasing the infiltration and therefore arresting the degeneration.

Behr's [7] attempt to explain the pathogenesis of the various types of syphilitic optic nerve atrophy is a hypothesis based on these facts, but,

7. Behr, C.: München. med. Wchnschr. **73**:366, 1926.

of course, still a hypothesis. According to his concept, basilar syphilis is a disease of the mesodermal tissue, and the optic nerve atrophy is due to a syphilitic optic neuritis involving the intracranial portion of the nerve. There is an infiltration of the septums, especially around the small vessels, with subsequent nutritional disturbances of the nerve tissue. The nerve tissue, reduced in its resistance, is further damaged by toxic products of the treponemes. Antisyphilitic drugs, if they are not used in too late a stage, clear up the nutritional difficulties, with resulting improvement in the visual disturbances. The pathologic process in the optic nerve associated with tabes and dementia paralytica, however, may start in any part of the nerve. Inflammatory signs do not play an important role. Two kinds of changes are important. The one concerns the septal system. Part of the fine septums is destroyed, and with them the nourishing capillaries; another part becomes shortened and thickened. Still more important are structural and chemical changes in the glial system. As this system is the main factor in normal nutrition of the nerve tissue, the changes in the glia and the disappearance of capillaries are considered the cause of the degeneration of the nerve fibers and of the irreversibility of the process with treatment. The pathologic process is due to the effect of the undetermined toxins of the treponemes.

SURGICAL TREATMENT OF CONCOMITANT DIVERGENT STRABISMUS

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AND
C. S. O'BRIEN, M.D.
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THE SURGICAL treatment of concomitant exotropia is said not to be as satisfactory as that of esotropia. This does not seem to be true, but it is difficult to predict the exact result of an operation, since the outcome is variable even when the operation is performed by the same surgeon employing the same technic.

Lancaster [1] stated that theoretically in correction of squint of lesser degree a 1 mm. movement of muscle insertion should shift the eyeball 2 degrees. Jameson [2] and Chavasse [3] advocated 1 mm. of recession of the lateral rectus muscle for each 2 degrees of correction desired, but Gifford [4] stated that 1 mm. of recession of the lateral rectus results in an average of only 1.5 degrees of correction.

In an effort to determine the average amount of correction resulting from certain operative procedures, statistics were compiled from 49 consecutive cases, in each of which the patient had been observed for more than one year after operation.

Divergent squint developed in the majority of patients after the age of 6 years, in contrast with the convergent type. The age of onset was at 6 years or more in 60 per cent of patients and under 6 years in 40 per cent.

Fixation varied, as it does in convergent squint, being alternating in 58 per cent of patients and monocular in 42 per cent.

Visual acuity was 6/9 or better in each eye in 55 per cent of patients and 6/30 or less in one eye in 18 per cent. Only 3 eyes showed

From the Department of Ophthalmology, State University of Iowa College of Medicine.

1. Lancaster, W. B., in Berens, C.: The Eye and Its Diseases, Philadelphia, W. B. Saunders Company, 1936.

2. Jameson, P. C.: Entity of Muscle Recession: Short Résumé of Its Technic and Principles with New Supplementary Notes and Illustrations, Arch. Ophth. **21**: 362 (Feb.) 1939.

3. Chavasse, F. M., in Worth, C.: Worth's Squint, revised by F. B. Chavasse, ed. 7, Philadelphia, P. Blakiston's Son & Company, 1939.

4. Gifford, S. R.: A Textbook of Ophthalmology, Philadelphia, W. B. Saunders Company, 1938.

a pathologic condition interfering with visual acuity, 2 having scarred corneas and 1 a macular lesion. In 37 per cent of patients the visual acuity differed in the two eyes at least two lines on the Snellen chart.

Hypermetropia in each eye was present in 60 per cent of patients, but only 1 showed more than 3.00 D. of hypermetropia and only 1 had anisometropia of over 2.00 D. Only 14 per cent of the patients were myopic in both eyes, and none had an error of over 2.00 D. Antimetropia (hypermetropia in one eye and myopia in the other) was found in 26 per cent of these patients. Retinal correspondence was normal at first examination in 70 per cent of the patients and abnormal in 22 per cent and changed from abnormal to normal after orthoptic training in 8 per cent. Convergence insufficiency plus divergence excess was noted in 53 per cent of patients and divergence excess alone in 47 per cent. Patients with convergence insufficiency alone were not included in this study.

In 49 cases the operations were performed by one surgeon, employing the same technic; thus, results should be comparable. Three operations, alone or in combination, were employed, namely (1) recession of the lateral rectus muscle, (2) resection of the medial rectus muscle and (3) resection and advancement of the medial rectus muscle.

The great discrepancy in results following operations for concomitant divergent strabismus may be noted in the accompanying tabulations.

Recession on Lateral Rectus Muscle of One Eye

Squint, Degrees	Recession, Mm.	Correction, Degrees
0-10	5	4
(7 cases)	6	8
	5	6
	4	3
	6	10
	6	8
	5	8
	Average 5.3	Average 6.7

One millimeter of recession corrected an average of 1.2 degrees of squint.

11-20	5	5
(6 cases)	7	10
	5	16
	6	10
	5	10
	6	7
	Average 5.7	Average 9.7

One millimeter of recession corrected an average of 1.7 degrees of squint.

21 or more	5	13
(2 cases)	7	11
	Average 6	Average 12

One millimeter of recession corrected an average of 2 degrees of squint.

In looking over these figures, one is struck by the great variation in the results of similar amounts of recession. For example, a 5 mm. recession resulted in corrections of from 4 to 16 degrees! One does gain the impression that the greater the degree of squint the greater the correction after similar amounts of recession.

Bilateral Recession of Lateral Rectus Muscle

Squint, Degrees	Total Recession, Mm.	Correction, Degrees
10-20	11	13
(6 cases)	9	10
	10	8
	10	16
	10	6
	10	9
	Average 10	Average 10.3

Thus, 1 millimeter of recession corrected an average of 1 degree of squint.

These results are not comparable to those obtained with a unilateral recession, in which each millimeter of recession corrected an average of 1.7 degrees of squint.

Resection of Medial Rectus Muscle of One Eye

Squint, Degrees	Resection, Mm.	Correction, Degrees
0-10	8	8
(12 cases)	10	8
	10	2
	12	6
	8	10
	8	8
	10	8
	6	5
	10	2
	10	3
	5	9
	8	7
	Average 8.6	Average 6.3

Here, each millimeter of resection corrected an average of only 0.73 degree of squint.

This operation when used alone was more unpredictable in its results than was recession; e. g., 10 mm. of resection resulted in from 2 to 8 degrees of correction. Furthermore, it had less effect than any single operation.

Recession of Lateral Rectus and Resection of Medial Rectus Muscle (on Same Eye and at Same Time)

Squint, Degrees	Total Recession and Resection, Mm.	Correction, Degrees
11-20	15	12
(5 cases)	15	15
	15	16
	16	20
	8	12
	Average 14	Average 15
21-30	15	21
(3 cases)	15	9
	14	13
	Average 14.6	Average 14.3

Each millimeter of recession or resection corrected an average of 1 degree of squint.

Here, again, there is inconsistency in results; e. g., 14 mm. of recession and resection resulted in from 9 to 21 degrees of correction. However, most results were reasonably alike.

Resection and Advancement of Medial Rectus Muscle

Squint, Degrees	Resection and Advancement, Mm.	Correction, Degrees
10-20	R 5	
	7	10
(4 cases)	A 2	
	R 10	
	11	14
	A 1	
	R 5	
	7	6
	A 2	
	R 10	
	12	15
	A 2	
	Average 9.2	Average 11.1

One millimeter corrected an average of 1.2 degrees of squint.

Recession of Lateral Rectus Muscle and Resection and Advancement of Medial Rectus Muscle (on Same Eye and at Same Time)

Squint, Degrees	Recession Total Resection-Advancement, Mm.	Correction, Degrees
20-30 (6 cases)	16	21
	15	17
	16	25
	12	25
	18	28
	18	23
	Average 15.8	Average 23.1

One millimeter corrected an average of 1.4 degrees of squint.

30+ (4 cases)	16	17
	18	39
	17	35
	20	36
	Average 17.7	Average 31.7

One millimeter corrected an average of 1.8 degrees of squint.

These results were perhaps the most consistent, although it is realized that in 1 instance a 15 mm. change in the muscles corrected only 17 degrees of squint, while in another case an 18 mm. change in the muscles produced 39 degrees of correction.

It is stated in the literature that one should recess the lateral rectus muscle in cases of divergence excess and that in correction of divergence excess plus convergence insufficiency the lateral rectus muscle should be recessed and the medial rectus muscle resected or resected and advanced. Theoretically, this reasoning is excellent and logical, but our figures do not bear out the necessity of differentiating the types of squint in order to choose the proper operation. Recession of the lateral rectus was equally effective in correction of each type of squint; resection of the medial rectus alone gave quite unpredictable results but was apparently just as effective in one type of squint as in the other. Results in cases in which a single operation was performed were as follows:

Recession of Lateral Rectus Muscle

	Recession, Mm.	Correction, Degrees
Divergence Excess (7 cases)	5	12
	5	4
	7	6
	4	2
	7	10
	5	16
	5	8
	Average 5.4	Average 8.3

One millimeter corrected 1.5 degrees of squint.

Divergence Excess	10	9
plus	6	10
Convergence Insufficiency	5	10
	Average 7	Average 9.7

One millimeter corrected 1.4 degrees of squint.

Resection of Medial Rectus Muscle

	Recession, Mm.	Correction, Degrees
	8	8
Divergence Excess	10	8
(4 cases)	10	8
	6	5
	Average 8	Average 7

One millimeter corrected 0.9 degrees of squint.

Divergence Excess	8	0
plus	10	2
Convergence Insufficiency	10	3
	8	7
	Average 9	Average 3

One millimeter corrected 0.3 degree of squint.

It may be stated that there was little apparent difference in the effect of an operation in cases of divergence excess and in cases of divergence excess plus convergence insufficiency.

Relation of the Type of Squint to the Effect of Operation

Deviation, Degrees	Divergence Excess No. of Cases	Correction (for Each Mm. Muscle)	Divergence Excess Plus Convergence Insufficiency	Correction (for Each Mm. Muscle)
0 - 10	5	0.7	6	0.64
11 - 20	11	1.1	6	1.0
21 - 30	4	1.3	9	1.5
31 - 45	1	1.4	5	1.6

One would expect that the results in patients with normal retinal correspondence would be better than in those with abnormal correspondence. Of the 38 patients with normal correspondence, 8 had undercorrection, with a residual exotropia of from 3 to 8 degrees, and 3 had overcorrection, 2 having 2 degrees of esotropia and 1 7 degrees. Two of 11 patients with abnormal retinal correspondence had undercorrection, 1 having 3 degrees and the other 16 degrees of exotropia; 1 patient had overcorrection of 1 degree. It seems that normal retinal correspondence is of no particular value so far as the result of operation is concerned, but it should help to keep the eyes in alinement.

Results are satisfactory in cases with abnormal retinal correspondence when the appearance of the patient is such that the squint

goes unnoticed. With 2 or 3 degrees of residual exotropia or esotropia the cosmetic result is good. In patients with normal retinal correspondence one desires parallelism, or only a low degree of residual exophoria. On the basis of these criteria, 10 of 49 patients had an undercorrection, i. e., an exotropia of 3 or more degrees (9 patients had from 3 to 8 degrees, and 1 patient with eccentric fixation had 16 degrees). Four of the 49 patients had overcorrection—1 patient had 1 degree of esotropia, 2 had 2 degrees and 1 had 7 degrees.

CONCLUSIONS

Results of operations in concomitant exotropia appear to be extremely variable, even with a standard technic in the hands of the same surgeon.

If the operation is confined to one eye it is difficult to overcorrect the higher degrees of exotropia.

Retinal correspondence appears to have no bearing on the surgical result.

The exotropia of divergence excess and that of divergence excess plus convergence insufficiency apparently respond equally well to operation, and it is not necessary to differentiate the type of defect in order to decide on the operative procedure.

In correction of the moderate and higher degrees of divergent squint, it is advisable to make an operation on both the lateral and the medial rectus muscles at the same time. This is in contradistinction to the procedure for convergent squint, in which it is best to make a two stage operation.

In spite of the variable results, the following operations are advised:

Exotropia of less than 10 degrees: recession of the lateral rectus muscle in one eye (from 4 to 7 mm.). One should expect approximately 1 degree of correction for each millimeter of recession.

Exotropia of 11 to 20 degrees: recession of the lateral rectus muscle and resection of the medial rectus muscle on one eye. The amount of recession is 5 to 6 mm. and the amount of resection 6 to 10 mm. One should expect approximately 1 degree of correction for each millimeter of change in the muscles.

Extropia over 20 degrees: recession of the lateral rectus muscle and rection and advancement of the medial rectus muscle on one side. The amount of recession is 5 to 6 mm., the amount of resection 6 to 10 mm. and the amount of advancement 2 to 3 mm. Approximately 1.5 degrees of correction may be expected from each millimeter of change in the muscles.

In any of these cases residual squint may be corrected by an operation on the opposite eye.

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CORNEAL VASCULARIZATION IN THE GRAY NORWAY RAT

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PHILADELPHIA

VASCULARIZATION of the cornea may be produced experimentally in animals by various means. Rabbits, dogs, rats and guinea pigs have been used with uniform success, and there is no evidence that a particular species or strain is more susceptible than another. Maintenance on a stock laboratory diet is generally accepted

Incidence of Corneal Vascularization

Age, Days	Number of Rats	Number of Rats with Vessels	Number of Eyes with Vessels	Percentage of Rats with Vessels
Norway Gray Rats				
Up to 500.....	40	3	4	7.5
Over 500.....	39	19	29	48.7
Albino Rats				
Up to 500.....	26	0	0	0
Over 500.....	19	0	0	0

to be a safeguard against the spontaneous development of the condition. However, corneal invasion was discovered in a group of supposedly normal gray Norway rats that were not known to be suffering from any dietary deficiency or other pathogenic condition. Albino rats in the same colony were found to be free of corneal vascularization.

METHOD

The rats were born and raised in the Wistar Institute animal colony and ranged in age from 64 to 766 days. Their diet consisted of Purina dog chow pellets ad libitum, and greens (principally lettuce) given twice each week. This diet is theoretically adequate for the nutritional requirements of the rat. The eyes of 23 male and 22 female Wistar albino rats, and 37 male and 42 female domesticated gray Norway rats were examined. The pupils were dilated with 2 per cent homatropine hydrobromide, and the corneas were observed with an ophthalmoscope. Light ether anesthesia was employed to immobilize the young gray rats only.

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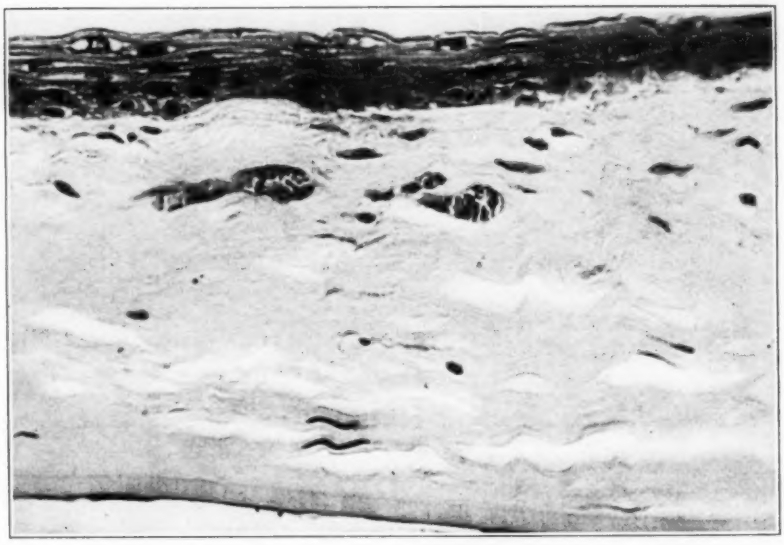
RESULTS

The data are presented in the accompanying table. Only 7.5 per cent of the gray Norway rats under 500 days of age, but 48.7 per cent of these rats over 500 days old, showed corneal vascularization. There was no significant difference in the incidence with respect to sex. None of the albino rats showed corneal vascularization at any age. The photomicrographs of the cornea of a Norway gray rat shows vessels in the midstroma.



Vessels in the midstroma of the cornea. × 125.

COMMENT

The results indicate that corneal vascularization develops spontaneously in gray Norway rats, but not in Wistar albino rats, and that its incidence increases with age. Apparently, the two strains differ in susceptibility to the condition, but the cause of the difference is not known. Vascularization of the cornea can be brought about in many ways and by a variety of agents, both local and endogenous. Under the former may be listed bacteria, virus and protozoa; chemical agents, and burns. Endogenous agents include allergens; toxic material that spreads from an inflammatory focus and stimulates capillary ingrowth.

and nutritional deficiencies, either from a restricted diet or from an increased demand of the organism.

Some of these causes can probably be eliminated in a consideration of the etiologic factor responsible in the gray rats. The gray Norway rat may differ from the albino rat constitutionally, i. e., it may be more sensitive to burns, bacteria, allergy or food deficiencies.

The spontaneous incidence in gray Norway rats of corneal vascularization of unknown origin makes these animals useful as subjects for investigation of the underlying causes and as test animals in experimental work requiring the production or presence of vascular invasion.

SUMMARY

Corneal vascularization occurred in the Norway gray rats, but not in the albino rats, when the two strains were maintained on similar diets and in the same colony. Sex had no influence on the incidence of the vascularization. The vascularization increased with age and was most pronounced in Norway gray rats over 500 days old.

Clinical Notes

A SIMPLE METHOD FOR TEMPORARY CLOSURE OF THE LIDS

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IN CASES in which it is desirable to close the lids for a few days to a few weeks, or occasionally as a preliminary to lid suturing, I have found "glueing" the lids together a useful procedure.

The cases in which I have employed this method have chiefly been those in which there were facial paralysis and corneal anesthesia, so that exposure keratitis was thought to be an imminent possibility. Among such cases were instances of facial paralysis following intracranial operation or trigeminal resection (for tic douloureux), in which it was thought that the facial paralysis was not to be permanent, or instances of facial paralysis and corneal anesthesia resulting from spontaneous but transient intracranial lesions (aneurysms). When the paralysis persisted more than a few weeks, the lids were subsequently sutured. I have also used the procedure in cases of coma in which there was an exposure keratitis from incomplete closure of the lids; in these instances, however, the procedure is preferable to taping only when the restlessness of the patient makes the taping unsatisfactory. In 1 instance the lids of one eye were glued together to avoid a diplopia for which a patch was too "bothersome."

The "glue" which I have employed is the standard Duco cement,* which is commercially available in hardware or variety stores. The procedure consists in closing the patient's eyes and applying by means of a tooth pick applicator several layers of the cement to the lashes of the upper lids, sealing them down to the cutaneous surface of the lower lid, at first 1 to 2 mm. below the margin of the lower lid. Time is allowed for drying of each layer, and subsequent layers are placed higher up so as to occlude ultimately the palpebral fissure and form a cast covering much of the upper and lower lids. The medial ends of the lids are not stuck together, however, so that tears and secretory products may drain out of the conjunctival cul-de-sac.

The cast provides a firm cohesion of the lids lasting 3 to 5 weeks. At first transparent, it may become partially opaque by reason of air bubbles within it; yet it is never conspicious cosmetically. When it finally comes off, it may remove several of the cilia with it, but this is of no practical consequence.

The only complication I have encountered in the 10 cases on which I have used the method is a sensitivity reaction, in 1 instance. In this case there developed considerable swelling of the lids and redness on the seventh day following its application. The swelling promptly disappeared after removal of the cast, and the lids were then sutured. There is, of course, some danger of bringing the fresh cement in contact with the cornea, but if the substance is applied carefully and the lids are kept closed manually while the cement is being applied, this danger is negligible.

Howe Laboratory of Ophthalmology, Harvard Medical School.

A SIMPLE AND EFFICIENT CATARACT SUTURE

JOSEPH LAVAL, M.D.
NEW YORK

THERE are so many different types of cataract sutures in use that I hesitate to present still another. However, at the Manhattan Eye, Ear and Throat Hospital this one has proved very efficient and easily used as well as at the Mount Sinai Hospital, where the residents in ophthalmology have been using it.

There are several general classes of corneoscleral sutures: (1) the preplaced sutures, such as the Stallard, the MacLean and the Verhoeff; (2) sutures placed after the section such as the Kirby; (3) sutures placed partly before and partly after the section, such as the Castroviejo. The suture I present is a compromise between the preplaced suture and the suture placed after the section, the compromise consisting in making a small 5 mm. keratome section and then placing the suture. It is somewhat similar to the Perrera type.

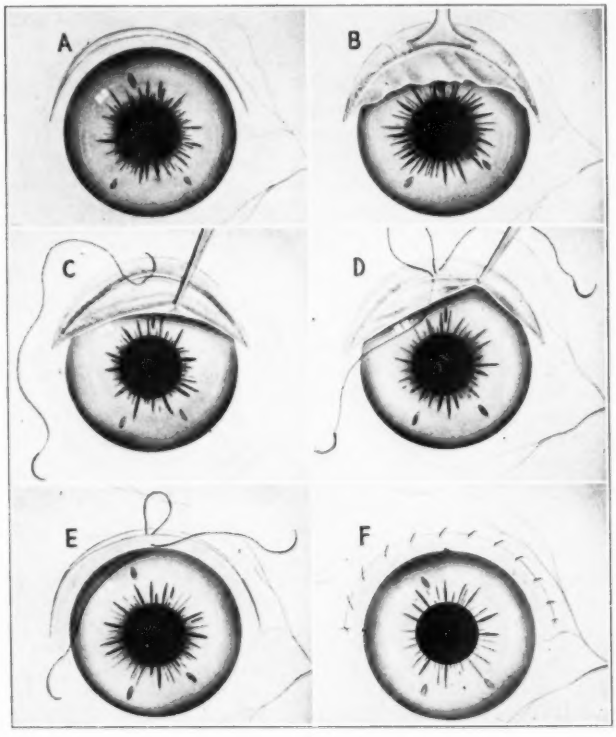
After lid akinesia and retrobulbar injection of procaine, two silk sutures are placed in the upper lid, one in the lower lid and one through the superior rectus muscle, as a bridle suture. No speculum is used. A conjunctival incision is made 5 mm. from the limbus for one-half the circumference of the cornea (figure, *A*). The conjunctiva is undermined to the limbus, and the corneoscleral junction is exposed in the region of 12 o'clock.

A keratome incision about 5 mm. long is made at this point (figure, *B*). One needle of a double-armed suture (000000 silk with a traumatic needle) is passed through the outer layers of the scleral lip of the keratome wound, the point of the needle facing the surgeon (figure, *C*). The other needle of the double-armed suture is passed through the corneal lip of the keratome wound, the needle tip facing away from the surgeon (figure, *D*). The first needle, which passed through the scleral lip, is now taken through the conjunctiva close to its attachment to the corneal lip, the tip of the needle facing away from the surgeon (figure, *E*). The suture is looped away from the wound and a loose tie taken. The section is enlarged with scissors. A peripheral or a complete iridectomy is performed, the lens is removed, and then the suture is firmly tied, the corneal and the scleral edges of the wound being brought snugly together. The conjunctival incision is closed by a running silk suture (000000), with a knot tied firmly at each end of the suture (figure, *F*). This gives good tight conjunctival closure. If the surgeon likes to put an air bubble into the anterior chamber, he does this after the conjunctiva has been closed. The patient is often

Read at a meeting of the Section of Ophthalmology of the New York Academy of Medicine, Oct. 18, 1948.

sent from the operating room with the eye not operated on uncovered. He is allowed out of bed the day after the operation. Postoperative complications, such as prolapsed iris or hyphema, are extremely infrequent. Postoperative astigmatism is kept at a minimum.

I realize that most surgeons do not like to place cataract sutures after the section has been made. I believe that this objection is over-



Steps in placement of a new cataract suture.

come by making a 5 mm. keratome section and then placing the sutures before the section is enlarged. Grasping of the scleral and corneal edges of the wound with mouse-toothed forceps at this stage for insertion of the sutures is free of any hazards. I have never had any trouble or complications while doing it. The method has an advantage over use of the Kirby suture with conjunctival flap in that the suture is placed after a very small incision (5 mm.) has been made. It has one advantage

over the Verhoeff and MacLean sutures in that it is much more easily and more quickly placed. The possible advantage of the MacLean and Verhoeff sutures in that they may be placed before the section is made is more than counterbalanced by the difficulty encountered in making the section after the suture is in place. The only advantage of my method over Perrera's is that only one suture has to be placed, and I am firmly convinced that one good suture is enough. I must admit, however, that one objection can be made to my method; that is the theoretic possibility of an ever so slight malplacement of the corneal and scleral bites, so that the two lips of the wound are not in exact microscopic apposition. To my mind, however, that is a purely theoretic, and not a practical, objection.

136 East Sixty-Fourth Street (21).

News and Notes

EDITED BY DR. W. L. BENEDICT

UNIVERSITY NEWS

Research on Corneal Transplantation, Stanford University School of Medicine.—Research on corneal transplantation will be carried out by Dr. Alfred E. Maumenee, head of the ophthalmology department at the Stanford University School of Medicine, under a contract with the National Advisory Council of the United States Public Health Service.

Dean Loren R. Chandler, of the medical school, in announcing receipt of the grant, said that the funds included an allowance for a research fellow and that applications for the fellowship are requested by the medical school.

The research grant is for one year but is subject to renewal.

SOCIETY NEWS

The American Ophthalmological Society.—The officers elected at the recent meeting of the American Ophthalmological Society are Dr. Parker Heath, president; Dr. John H. Dunnington, vice president, and Dr. Maynard C. Wheeler, secretary-treasurer.

Correspondence

COMMENTS ON DR. RAND'S LETTER ON HARTRIDGE'S ARTICLE ON PHYSIOLOGY OF VISION

To the Editor:—May I make a few comments on the review of some of my papers which Dr. Rand contributed to the October 1947 issue of the ARCHIVES, page 529? She refers to Granit's work on animals with the microelectrode and to my attempts to investigate the properties of the human retina, using an optical instrument called the retinal microstimulator. She states, "Hartridge utilized 'tenuous beams of light' sufficiently narrow to subtend at the eye an angle of only 8 seconds of arc and to form on the retina, he claims, geometric images equal to one-fifth cone unit. (One 'cone unit,' according to Hartridge, subtends an angle at the observer's eye of 41.236 seconds of arc)." This is quite true, but I have pointed out with great care that the diffraction of light and the residual aberration of the human eye must cause the light of which the retinal image is comprised to spread far beyond the boundaries of its geometric image, because no optical contrivance at present known enables an image to be formed on the retina which is smaller than that based on the wave theory of light. By a careful adjustment of the conditions, however, the retinal image may be made to look to the observer far smaller and more sharply defined than would be expected on the basis of optical theory alone. The diffraction pattern of a point source of light when it falls on the retina probably acts as an adequate stimulus for 20 foveal receptors, if not many more. It might be supposed, therefore, that this number of receptors at least would form a functional unit. How wrong this idea is may be gaged from the fact that most normal-sighted observers can recognize the letters of the alphabet when they subtend at the eye 5 minutes by 4 minutes of arc, that is, that the geometric images of the letters on the retina fall on roughly 45 foveal receptors. Now the diffraction patterns of the various parts of these letters must overlap one another at every point, causing a blur of light which spreads over probably more than 100 foveal receptors. It might be concluded, therefore, that the resolution of the letters would be impossible under such conditions. But this conclusion would be completely at variance with the facts, because resolution is found to be quite easy under the conditions mentioned; in fact persons who have good acuity can sometimes identify letters when they subtend at the eye half the aforementioned angles, in which case the individual black and white parts of the letters must have widths which correspond to less than 1 cone unit. These are the conditions I aim at when using the microstimulation apparatus, and they are not at variance with the diffraction theory of light. The results achieved show that diffraction is by no means the only factor so far as human vision is concerned, for the evidence available is in favor of the idea that the retinal image which is impaired by diffraction and the aberrations is repaired again by processes at present but little understood.

Thus, when an observer with good visual acuity examines a point source of monochromatic light by using the optimum part of his fovea, a diffraction pattern of that object is cast on his retina which, as previously explained, has a diameter equal to many cone units. But the processes of repair, which must take place somewhere between the retina and the perceptual centers of the brain, have the effect of reducing the apparent diameter of this image until it is little larger than 1 cone unit. There can be little doubt that repair is greatly assisted by the physical distribution of light in the retinal image. Calculation has shown that under ordinary conditions of vision if the intensity of illumination of the foveal receptor is 100, on which the center of the diffraction pattern falls, then the circle of cones around this central cone receives illumination equal to 10; the circle outside these cones again, receives illumination equal to 2; the next circle, less than 0.5, and so on. Thus the central receptor receives a much higher intensity of illumination than any of the other receptors.

With regard to the processes of repair referred to, the sharpening of diffuse contours has long been known and has been described as one of the attributes of simultaneous contrast.

Before passing on, one must refer to the practical aspect and consider how effective these processes of repair really are. Does the diffraction pattern ever stimulate adequately so small a retinal area that the nervous message to the higher centers comes from one receptor only? The answer is "yes," without any possibility of doubt. But this limitation is as a rule achieved only when many point sources, close to one another in cone units, are being looked at. In cases in which only one source is being examined, or in which other sources are also present but are many cone units apart, this sharp limitation is not achieved as a rule. But what is achieved quite easily is a limitation to 1¼ cone units, that is, to about 50 minutes of arc. One is now in a position to examine critically the point raised by Dr. Rand, namely my insistence that the geometric image on the retina of the source of light should be as small as possible, in any case not larger than ⅓ cone unit. Why, it may be asked, is it necessary to consider the geometric size of the image in view of the fact that its diffraction pattern is so large? The reply is that that geometric size is kept as small as possible in order to concentrate the greater part of the light into the central bright spot and to keep small the physical dimensions of this spot. Thus, a point source having a geometric image on the retina with a diameter equal to $\frac{1}{10}$ cone unit is found by experiment to have a physiologic diameter of about 1¼ cone units, and another source having a geometric image equal to 1 cone unit is found by experiment to have a physiologic diameter of about 2 cone units. Thus the smaller the geometric diameter, the better. It is for this reason that in my microstimulation apparatus the geometric image is kept small and its size is stated in cone units, so as to guide other research workers who employ this or similar methods.

Dr. Rand points out that my fixation experiments are at variance with the results of Adler and Fliegelman. Such is the case; but (1) my fixation results have been confirmed and extended by Thomson using another method; (2) the unsteadiness found by Adler and Fliegelman may have been a peculiar feature of the single human subject whom

they used for their experiments or may have been due to the method which they employed, which included the use of a flat mirror adhering by surface tension to the curved surface of the sclera; and (3) it is possible that head movements also occurred during the time that the records of ocular movements were being performed. With regard to the last factor mentioned, experiments have recently been performed by Thomson and myself using a method which records eye movements without accompanying head movements. We found astonishing steadiness of the eye during fixation.

Dr. Rand points out that the fixation experiments were performed on only one eye of one observer. This is true. England was engaged in war when these experiments were being performed, and no other subject was found who could spare the time. Only one eye of the subject was used because the other one had inferior visual acuity, which precluded its use for this type of experiment.

With regard to color blindness, Dr. Rand points out that I do not discuss Wright's alternative suggestions for explaining these situations on a trichromatic basis. The reason was that on the whole Dr. Wright's explanations appear to be correct, for many, if not most, color-blind subjects show few if any signs of polychromatic vision. It should be pointed out, however, that, in my opinion, Dr. Wright's explanations of protanomalous trichromatism cannot be regarded as satisfactory, because supporters of the three color theory have given no satisfactory account of the differences in visual perception of normal subjects and of persons with anomalous trichromatism.

Now let us consider hue discrimination. Dr. Rand regrets that I illustrated my arguments with a hue discrimination curve for one subject with normal color vision, "since this curve departs markedly from the careful determinations of other investigators, including the recent work of Wright and Pitt." There seems to be a mistake here. The hue discrimination curves which I considered were those obtained by Steindler, by Jones and by Laurens, and Hamilton. Of Steindler's results, Sir John Parsons stated that, in his opinion, "of these the most accurate and complete are those of Steindler."

In my opinion, Pitt and Wright found hue discrimination inferior to that obtained by the four other investigators mentioned, probably because of the conditions present during their determination. The Wright colorimeter is illuminated by a strip filament tungsten electric lamp, and narrow spectral bands are selected from the spectrum of this source. As a consequence, light intensity is low, and so measurements have to be carried out in a darkened room. The two fields to be compared subtend together about 2 degrees of arc, and they appear to lie on a black background. Thus the observers eye is in a state of partial dark adaptation, and conditions are not those which usually produce the best hue discrimination. How important may be this use of fully adequate illumination and of a bright surround is clearly seen in the case of high acuity for pattern detail; evidence is now coming to light that these same factors play an important part in achieving the best hue discrimination also.

With regard to the difficulty in explaining the change of hue undergone by colors when their visual angle is reduced or their illumination lowered, Dr. Rand fails to notice the important point, that the change

undergone by color vision when yellow is replaced by white is accompanied with a local fall in the brightness of the spectrum in this region, and that, similarly, the replacement of blue by black is correspondingly accompanied with a localized decrease of brightness, as has recently been demonstrated by Thomson. It is these localized decreases in brightness which accompany the color changes which present to the three color theory so much difficulty. Thus in order to account for the notch in the luminosity curve in the yellow spectral region, discovered by Sloan, the hypothesis was advanced by Forbes that the red receptors retain their sensitivity better than do the green ones or the blue ones. In order to account for the notch in the luminosity curve in the blue spectral region, which has recently been discovered by Thomson, a similar hypothesis must be advanced, namely, that the blue receptors retain their sensitivity better than do the green ones or the red ones. But at the same time that this notch appears, blue is seen to be replaced by dark gray, or even by black, and in order to account for this dramatic color change it is necessary on the basis of the three color theory to assume that the blue receptors are cut off partially or completely from the nerve paths which connect them with the blue-receiving center of the brain. The three color theory is therefore found to be on the horns of a dilemma, because in order to account for Thomson's notch the assumption has to be made that the activity of the blue receptors is enhanced; on the contrary, in order to account for the substitution of dark gray or black for blue, the assumption has to be made that the blue receptors are largely if not entirely, put out of action. But these assumptions are completely at variance with one another, so that either one or the other, but not both, phenomena can be accounted for. To summarize the situation with regard to foveal color vision of test objects which subtend small angles at the eye: In order to account for the observed phenomena on the basis of the three color theory, five supplementary hypotheses must be advanced. Not only do these lend one another no support, but they are not supported by any other evidence. Moreover, two of them are contradictory. Thus the three color theory fails altogether so far as this important phase of color vision is concerned.

This is not an isolated example of the failure of the three color theory to comply with the results of recent research, for an examination of other phases of color vision discloses the fact that it is in no better case with any one of these. The polychromatic theory, on the other hand, has so far been found to be in agreement with them.

Readers of this letter may like to have recent evidence concerning the polychromatic theory. The microstimulation method, which comprised the fixation point method and the subjective color method, provided evidence for the presence of a number of different receptors in the human retina. The approximate wavelengths of the crests of these receptors and the part they play in vision are now known with some degree of certainty.

Three types of receptors play a predominant role in foveal color vision at medium light intensities, and for fields of 2 degrees; these receptors have crests in the spectrum at about 0.60, 0.55 and 0.45 microns. They form together what I have called "the tricolor unit." These are assisted, under the conditions mentioned, by four other types

of receptors, which play a subsidiary part only: a crimson type of receptor, which has responses in the red (0.65 micron) and in the violet (0.42 micron); a yellow type (0.58 micron); a blue-green type (0.50 micron), and a blue type (0.48 micron). When, with foveal vision, the light intensity is slowly increased to a maximum, first the crimson and the blue-green receptors cease to function, and they are followed by the tricolor receptors, so that there is left a form of dichromatic vision mediated by the yellow and the blue receptors only. On the other hand, if light intensity is slowly decreased, it is the yellow and the blue receptors which are the first to go out of action, thus producing the notches in the luminosity curve which are found in the yellow and in the blue. With a further reduction of intensity, the tricolor receptors also lose activity, thus producing another form of dichromatism, for which the crimson and the blue-green receptors are responsible. The replacement of foveal vision by peripheral vision causes changes which resemble those produced by a high intensity of illumination, and a reduction of visual angle imitates the effects of a reduction of light intensity.

The acompanying table summarizes the points which have just been mentioned.

	Wavelengths (Micron) According to			Foveal Vision				
					Light Intensity			
Type of Receptor	Fixating Method	Subjective Method	Other Methods	Very Low	Low	Medium	High	Very High
Red	0.66	0.64	0.66	++	+	+	..	..
Orange	0.62	0.61	0.60	..	+	++	+	..
Yellow	0.58	0.575	0.578	..	..	+	+	++
Green	0.54	0.54	0.547	..	+	++	+	..
Blue-green	0.50	0.51	0.50	++	+	+	..	..
Blue	....	0.48	0.476	..	..	+	+	++
Blue-violet	0.46	0.45	0.45	..	+	++	+	..
Violet	0.42	0.42	0.42	++	+	+	..	..

Evidence concerning the other methods of investigation, referred to in the table, are in course of publication elsewhere.

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Abstracts from Current Literature

EDITED BY DR. WILLIAM ZENTMAYER

Anatomy and Embryology

NATURE OF THE INNERVATION OF THE CILIARY MUSCLE. P. MATTEUCCI, Ophthalmologica **114:** 377 (Dec.) 1947.

Histologic studies on human eyes apparently show that both portions of the ciliary muscles (the radial fibers of Brücke and Wallace and the circular fibers of Müller and Rouget) are innervated by parasympathetic and sympathetic fibers. The author was able to demonstrate not only nerve fibers covered by myelin sheaths, but also a network of fine neurofibers which end in the neighborhood of the smooth muscle elements.

H. P. KIRBER.

Conjunctiva

SURGICAL TREATMENT OF PTERYGIA FOLLOWED BY X-RAY THERAPY TO PREVENT RECURRENCE. H. L. HILGARTNER, R. T. WILSON and J. D. WILSON, Am. J. Ophth. **31:** 667 (June) 1948.

Hilgartner, Wilson and Wilson report gratifying results in 10 cases of pterygium following postoperative irradiation. They describe the roentgenologic technic.

W. S. REESE.

Cornea and Sclera

ROLE OF VITAMIN INSUFFICIENCY IN THE PATHOLOGY OF THE CORNEA. A. KATZNELSON, Vestnik oftal. **26:** 3, 1947.

Keratomalacia due to avitaminosis A in the mother is observed in infants, who may be born with dense opacities of the cornea. According to Katznelson's observations, the clinical picture varies in adults and in infants: Avitaminosis A is an early manifestation in infants, while in adults it appears later, possibly because of a reserve of provitamin A in the tissues. The characteristic involvement of the skin and mucous membranes in adults with keratomalacia is less evident in children. Both eyes are usually affected in children, while frequently in adults there is an interval between the involvement of the first and that of the second eye. The secondary purulent infection associated with keratomalacia is less severe in children. The course of the disease in patients with trachomatous pannus is atypical and frequently leads to diagnostic mistakes. In general, the process is more favorable in cases of vascularized corneas. Dystrophy of the cornea occurring in the course of diabetes and toxic diffuse goiter can be explained by endogenous avitaminosis A. The author observed true keratomalacia in a patient with acute hyperthyrotoxicosis. Lagophthalmic keratitis complicating infectious diseases may also be due to endogenous avitamino-

sis A. Tuberculous-allergic diseases of the eye are commoner in children with poor nutrition. The cutaneous reaction to tuberculin is also lowered in these children.

The author observed cases of disciform, herpetic keratitis due to thiamine insufficiency. There is a similarity in the clinical picture of neurotrophic and that of neurogenic keratitis of virus origin. The treatment of herpetic keratitis with intravenous injections of thiamine and local application of thiamine ointment gave good results.

Ariboflavinosis causes disturbance of the epithelium of the cornea and increase of the marginal loop vessels, rosacea keratitis and marginal ulcers. Administration of riboflavin is therefore indicated in treatment of these diseases of the cornea. Ascorbic acid is indicated in cases of phlyctens and tuberculous, keratitis and in chemical and thermal burns of the cornea. In the latter, 40 per cent dextrose solution with large doses of ascorbic acid led to a decided lessening of pain, and inflammatory reaction and to decrease in the secondary trophic disturbance of the cornea, with formation of thin scars.

O. SITCHEVSKA.

General Diseases

THE OCULAR SYNDROME OF CATARACT AND PAPILLEDEMA IN THE MANIFEST FORM OF PARATHYROID DEFICIENCY. D. J. LYLE, Am. J. Ophth. **31:** 580 (May) 1948.

Lyle reports the case of a woman aged 53 in whom parathyroid deficiency and cataracts developed after thyroidectomy. After cataract extraction of the second eye the patient became confused, disturbed and blind, except for light projection. Papilledema was found, and the fields were greatly constricted. Improvement resulted from use of calcium lactate and dihydrotachysterol.

W. S. REESE.

RUBEOSIS IRIDIS DIABETICA. JACK V. LISMAN, Am. J. Ophth. **31:** 989 (Aug.) 1948.

Lisman reports a case of rubeosis iridis associated with diabetes in which medical and surgical treatment failed and enucleation was necessary. The eye was examined histologically.

W. S. REESE.

LINDAU'S DISEASE—PROGRESSION IN AFFECTED FAMILY. A. E. MACDONALD, Brit. J. Ophth. **32:** 575 (Sept.) 1948.

MacDonald had the opportunity to follow the course of Lindau's disease in a family in which 3 of the 4 members of a sibship has each undergone successful removal of a cerebellar tumor, which on pathologic examination proved to be hemangioendothelioma. The diagnosis of cerebellar tumor was verified for sibling 1 at the age of 29 years by pathologic section, and a tumor of the eye was treated by radon seeds. In sibling 2 the cerebellar tumor was diagnosed at operation at the age of 23 years and by pathologic section of material obtained at two subsequent operations. The tumor in the eye presented a similar pathologic appearance. Sibling 3 had a nevus at the limbus of the left eye,

which was less apparent after nine years. The cerebellar tumor of sibling 4, the only male member, was diagnosed by pathologic examination at the age of 28; after extensive irradiation an ophthalmic tumor, of capillary type, has slightly progressed in four years.

W. ZENTMAYER.

OCULAR SYMPTOMS OCCURRING AFTER AMEBIC DYSENTERY AND IN CARRIERS OF THE INFECTION. V. MUCH, Ophthalmologica **114:** 384 (Dec.) 1947.

Over a number of years, Much collected data on more than 300 patients recovering from amebic dysentery and on carriers of Endameba histolytica. He found frequent blepharoconjunctivitis and discoloration of a sector of the temporal half of the optic disk, very similar to that observed in cases of disseminated sclerosis. He found no evidence of iritis. Positive reactions in the complement fixation test and the fluorescein test were accepted as proof of the disease in cases in which organisms were not found in the stool. Much gives 2 Gm. of alkaline fluorescein sodium by mouth and observes a gray discoloration of the aqueous humor under the slit lamp within twenty to thirty minutes in patients with intestinal parasites, liver or gallbladder disease. The same discoloration, however, is observed in cases of pregnancy and hyperthyroidism. In normal subjects a green discoloration appears as a rule in not less than one hour.

H. P. KIRBER.

Glaucoma

GLAUCOMA ASSOCIATED WITH SUBLUXATION OF THE LENS IN SEVERAL MEMBERS OF A FAMILY. J. P. HARSHMAN, Am. J. Ophth. **31:** 833 (July) 1948.

Harshman gives the genealogic tree of a family in which there were many cases of glaucoma associated with subluxation of the lens. In these cases the glaucoma was permanently controlled by removal of the lens.

W. S. REESE.

BETA IRRADIATION AS A POSSIBLE THERAPEUTIC AGENT IN GLAUCOMA: AN EXPERIMENTAL STUDY WITH THE REPORT OF A CLINICAL CASE. G. M. HAIK, L. A. BREFFEILH and A. BARBER, Am. J. Ophth. **31:** 945 (Aug.) 1948.

Haik, Breffeilh and Barber conclude from the results of rabbit experiments that beta irradiation of the ciliary body tends to obliterate the vascular supply and reduce the ocular tension. However, it also causes damage to the lens. A case in which it was tried on a hopeless human eye is presented.

W. S. REESE.

OPERATIVE FAILURES FOR CHRONIC SIMPLE GLAUCOMA: A HISTOLOGIC STUDY. B. F. PAYNE, Am. J. Ophth. **31:** 965 (Aug.) 1948.

Payne made a laboratory study of cases of operative failures in glaucoma and found in cases of iridectomy that synechias persisted and the root of the iris had not been removed. In iris inclusions there was

closure by the iris and in trephinations fibrotic and inflammatory changes closed the opening. Successful operations far exceed these laboratory "failures."

W. S. REESE.

A MODIFICATION OF ELLIOT'S OPERATION AND ITS APPLICATION TO HIGH TREPHINATION. W. ARKIN, Am. J. Ophth. **31**: 975 (Aug.) 1948.

Arkin modifies the Elliot operation by first making an incision as in cyclodialysis and introducing a spatula, which acts as a support for the trephine and prevents damage to underlying structures.

W. S. REESE.

SOME EXPERIMENTS WITH GREEN SPECTACLES PRESCRIBED TO GLAUCOMATOUS PATIENTS. R. B. ZARETSKAYA, Am. J. Ophth. **31**: 985 (Aug.) 1948.

Zaretskaya finds that wearing green spectacles reduces the tension in glaucomatous eyes and that this effect is reenforced by small doses of epinephrine.

W. S. REESE.

GLAUCOMA AND CATARACT. J. FRANCOIS, Ann. d'ocul. **180**: 457 (Aug.) 1947.

This article is limited to a discussion of the coincidental occurrence of glaucoma and cataract. Cases of cataract secondary to an operation for glaucoma or of glaucoma secondary to a cataract extraction are excluded. The author believes that cases of this nature are frequently overlooked. The presence of a cataract may account for the reduction in vision and obscure a good view of the fundus. The tension should therefore be taken routinely or other confirmatory tests of glaucoma performed if possible.

Cases may be of three types: 1. Chronic glaucoma and the coincident development of cataract. The glaucoma is the more important problem, and the cataract is momentarily of secondary significance. 2. Development of cataract in an eye that had previously been operated on successfully for glaucoma, with formation of a filtering cicatrix. 3. Chronic glaucoma with a high tension which has not been relieved by operation and operable cataract may exist together.

In cases of the first group, if miotics do not successfully control the tension, operation must be resorted to. The iris inclusion operation gives the best results in cases of this type.

In cases of the second category, the surgeon must decide whether he should operate on the cataract, whether he should perform an intracapsular or an extracapsular extraction and what type of operation should be performed so as not to interfere with the filtering cicatrix. The surgeon must be sure of his technic and must be of sufficient character not to hesitate to offer the patient every chance for a successful operation. The author believes that an intracapsular operation should be performed, since an extracapsular extraction predisposes to iridocyclitis and other postoperative complications. The only guide as to when

to operate is the amount of incapacitation produced by the reduction in vision. The type of operation selected should preserve the filtering cicatrix. This is best accomplished by making the corneal incision below and by extracting the lens in the usual manner, but through the inferior incision.

In cases of the last category, the surgeon must decide whether to operate for the glaucoma before or after the cataract extraction or whether to combine the two operations.

A discussion of the various procedures is presented. In the author's opinion an operation for glaucoma, such as iridencleisis, should be performed first. The cataract can be removed later when the eye is quiet.

P. R. McDonald.

Variations in General Arterial Pressure as a Causal Factor in Glaucoma. G. Cristini, Rassegna ital. d'ottal. **15:** 125, 1946.

The author studied the importance of variations in the general circulation as they relate to ocular pressure in glaucoma. He reviews the physiology of the circulation and the neurology of the uvea as these pertain to the hemodynamics of this structure for the regulation of ocular pressure.

He describes the results of three functional tests conducted on 20 glaucomatous patients: (1) inhalation of amyl nitrite with simultaneous recording of the ocular pressure and of the systolic arterial pressure in the arm; (2) phlebotomy and removal of 500 cc. of blood, followed by measurement of the ocular pressure, and (3) consensual response of the ocular tension after compression of the eyeballs.

The difference in the response of the patients to these three tests was noted, a difference which is related to the clinical type of this disease. The author feels that among the causative factors of glaucoma there are not only venous but arterial alterations in the afferent and efferent vessels of the uveal tract. This hypothesis is supported by the response of glaucomatous eyes to various hypotensive substances and is therefore of great importance in the treatment of glaucoma.

G. B. Bietti—J. J. Lo-Presti.

Retinal Folds After Operations for Glaucoma. A. Dellaporta, Ophtholmologica **116:** 51 (July) 1948.

A case of formation of retinal folds fourteen months after iridencleisis and cyclodialysis for juvenile glaucoma is reported. Retinal folds are not infrequently seen after such operations but are usually due to hypotony of the eyeball. In this case the tension fluctuated between 15 and 22 mm. of mercury. The folds disappeared when the tension rose to 26 mm. and reappeared again with a tension of 17 mm. They persisted for more than two months. They did not cause any metamorphopsia, decrease in visual acuity or changes in the visual fields. The folds were observed with the ophthalmoscope and the slit lamp. An explanation is offered that such folds may be the sequence of a relative hypotony of the eyeball.

H. P. Kirber.

Injuries

FURTHER EXPERIENCE WITH AMNIOTIC MEMBRANE GRAFTS IN CAUSTIC BURNS OF THE EYE. A. SORSBY, J. HAYTHORNE and H. REED, Brit. J. Ophth. **31:** 409 (July) 1947.

A further series of 28 cases of caustic burns of the eye treated by grafting with human amniotic membrane is recorded. When the previous and present series are considered together, it appears that remarkably rapid response may be expected when grafting is applied on the same day, or within twenty-four hours after the injury; subsequent recovery is slower. Apparently, the amniotic membrane does not stimulate growth, but acts as a sort of internal splint for the proliferating tissue. The method of preparing the amniotic membrane is described.

W. ZENTMAYER.

Instruments

OPACITY METER FOR CORNEA AND LENS. H. M. DEKKING, Ophthalmologica **115:** 219 (April) 1948.

The author stresses the need of an objective method for the measuring of changes in density of corneal opacities and cataractous lenses. Repeated determinations of visual acuity are not objective, and slit lamp photography is too expensive. An instrument originally devised by Dekking in 1936 has been improved on (illustration). It consists essentially of a photometer which measures the brightness of an image formed by the anterior segment of the eye.

H. P. KIRBER.

Lens

CANCER AND THE LENS. E. SACHS and R. L. LARSEN, J. Ophth. **31:** 561 (May) 1948.

Sachs and Larsen discuss factors of biologic, metabolic, physical and chemical nature, any or all of which may be responsible for the immunity of the lens to cancer.

W. S. REESE.

IMPORTANCE OF ZONULOTOMY FOR TOTAL PHACECTOMY (INTRACAPSULAR CATARACT EXTRACTION). L. D'ANDRADE, Ophthalmologica **115:** 78 (Feb.) 1948.

The author has devised a zonulotome which he uses in cases of hypermature, morgagnian and intumescent cataracts and the cataracts of high myopia. After rupturing the lower half of the zonule, he applies pressure to the lowest part of the cornea and effects tumbling of the lens. He uses a special fork-shaped instrument which catches the lens at the limbus and removes it.

H. P. KIRBER.

Methods of Examination

THE STEREOPHOTOGRAMMETRIC STUDY OF THE ANTERIOR SEGMENT OF THE EYE. E. V. BERTOTTO, Am. J. Ophth. **31:** 573 (May) 1948.

Bertotto describes a new method of obtaining all the curves which make up the anterior segment of the eye based on the application of

stereophotography to ophthalmology. Because of the transparency of the conjunctiva and cornea, he powders the eye with a contrasting medium. The results obtained were better than were expected, the margin of error being only 0.017 mm. This method should be of great value in the manufacture of contact lenses. W. S. REESE.

Neurology

WARREN TAY-SACHS DISEASE IN A CHINESE INFANT. G. HARIDAS, Brit. J. Ophth. **31:** 428 (July) 1947.

A case of amaurotic family idiocy occurring in a Chinese Hylam male infant is reported, the first of its kind from Malaya. The child was 20 months and 20 days old when he died. The diagnosis was based on the progressive muscular weakness, lack of mental development and blindness, with pathognomonic changes in the fundus.

The article is illustrated. W. ZENTMAYER.

Ocular Muscles

NOTE ON THE POSITION OF THE EYE IN A THIRD NERVE PALSY. E. WOLFF and HEFFERNAN, Brit. J. Ophth. **31:** 427 (July) 1947.

A photograph of a patient is shown to demonstrate that with complete third nerve palsy the eye is abducted but, as in this position the superior oblique muscle cannot depress the eye, or only slightly, the amount of depression is minimal or nil. In the case reported, the paralysis was in the left eye, and when the lid was lifted manually the eye was seen to be directed directly outward. The corneal images were on the same horizontal level. W. ZENTMAYER.

Operations

SOME NEW POINTS IN THE TECHNIC OF IMPLANT IN TENON'S CAPSULE AFTER ENUCLEATION. A. FAVORY, Brit. J. Ophth. **32:** 366 (June) 1948.

Favory is of the opinion that an implant of 10 mm. in diameter is sufficient. Acrylic resin is the material used. The implant is spherical and slightly flattened posteriorly. Four small arches made of acrylic resin are fixed near the anterior surface to receive the tendons of the rectus muscles. On the anterior aspect a spur 15 mm. long and quadrangularly prismatic is drawn out. On the implant body are four grooves for easing the muscle looping. At the end of the operation only the spur protrudes from the conjunctival covering; the spur later fits into a hole on the posterior surface of the prosthesis. Silk sutures are used.

The necessary cuts for an understanding of the technic are supplied. W. ZENTMAYER.

A NEW OPERATION FOR IRIDODIALYSIS BY MEANS OF AN IRIS SUTURE. A. GARDILČIĆ, Ophthalmologica **115:** 141 (March) 1948.

Two cases of traumatic iridodialysis are reported in which the author used a corneoscleral surgical suture which unites the lips of the

wound after keratome incision, catches the root of the iris and emerges subconjunctivally under a Kuhnt-Pflüger flap. H. P. KIRBER.

Orbit, Eyeball and Accessory Sinuses

MICROPHTHALMOS. G. FORBES, Brit. J. Ophth. **30:** 709 (Dec.) 1946.

In the case reported the clinical diagnosis was bilateral microphthalmos, but, as in many such cases, histologic examination demonstrated the presence of a cyst attached to the lower anterior part of the eye. A female infant was born after completing the sixth month of intrauterine life, but before reaching the seventh month. The infant lived thirty hours. Besides the ocular abnormalities, there were supernumerary digits on the ulnar side of the right hand. The cyst was not completely cut off from the cavity of the eye, and fragments of disorganized retinal tissue passed through the gap. The interior of the cyst contained a mass of plicated, disorganized retina, being opposed to the choroid in some places and to the fibrous wall of the cyst in others, and also apparently lying free in the cystic cavity. The outer wall of the cyst was continuous with the sclera and appears to be of the same consistency, and in other places it was much less dense. This finding suggests that the wall was imperfect and had been reenforced by condensed orbital fibrous tissue. The article is illustrated.

W. ZENTMAYER.

EXPULSIVE HEMORRHAGE: TWO REMARKABLE ANATOMIC DISCOVERIES. W. A. MANSCHOT, Acta ophth. **19:** 237, 1941.

The author examined 2 globes, in each of which an expulsive hemorrhage had occurred. In 1 eye there was observed an angioma arising from one of the branches of a vortex vein. In the other eye there were areas of necrosis in the ciliary arteries, together with thrombus formation. The author believes that the vascular necrosis was the result of glaucoma, with which the eye had been affected for many years.

O. P. PERKINS.

Physiology

ON OBJECTIVE ADAPTOMETRY. G. H. JONKERS, Ophthalmologica **114:** 397 (Dec.) 1947.

The method first devised by Rieken (1943) was improved on by the author, who measures optokinetic nystagmus in dark adaptation by means of an improved adaptometer, a cathode ray oscillograph and a string galvanometer for registering the movements of the eye. He was able to measure objectively a 10^5-fold increasing sensitivity.

H. P. KIRBER.

STEREOSCOPIC VISION IN LIGHT AND DARK ADAPTATION. A. GUGGENBUHL, Ophthalmologica **115:** 193 (April) 1948.

Central and peripheral stereoscopic vision were determined in light and dark adaptation by means of an apparatus originally described by

Monje. For central vision in dark adaptation the threshold was found to be three times as high and the threshold for peripheral vision 1.7 times as high as that in light adaptation. Findings of earlier investigators were confirmed in general, and the differences were explained by comparing the different technics. The fact that the threshold of peripheral vision increases threefold in daylight and hardly changes in dark adaptation proves that stereoscopic vision of the dark-adapted eye is a function of the paracentral parts of the retina. Stereoscopic vision decreases toward the periphery of the retina in the same manner as does the visual acuity.

H. P. KIRBER.

Retina and Optic Nerve

FAT EMBOLIZATION INVOLVING THE HUMAN EYE. M. H. FRITZ and M. J. HOGAN, Am. J. Ophth. **31:** 527 (May) 1948.

Fritz and Hogan discuss the etiology and mechanism of the production of fat emboli. They report a case in detail, describing the clinical and pathologic findings. The fundi showed round and oval, white subretinal exudates completely surrounding both maculas and following the course of the main retinal vessels. The macula in the right eye appeared cherry red. There were no hemorrhages. W. S. REESE.

CAPILLARY HEMORRHAGES OF THE RETINA AND CAPILLARY FRAGILITY. J. GOEDBLOED, Ophthalmologica **115:** 174 (March) 1948.

Common causes of capillary hemorrhages are trauma, toxic and inflammatory processes, blood dyscrasias, arteriosclerosis, hypertension and diabetes. The Göthlin index is best suited to the measurement of capillary fragility. The American literature on butin is reviewed in part, and 2 cases are reported in which the condition was successfully treated with this drug.

H. P. KIRBER.

Uvea

CUTANEOUS ALLERGY TO TUBERCULIN IN IRIDOCYCLITIS. M. DUBOIS-POULSEN and DUBOIS-VERLIERE, Ann. d'ocul. **181:** 65 (Feb.) 1948.

Investigation on cutaneous allergy in cases of tuberculous uveitis has been generally neglected. The frequent positive cutaneous reactions in adults makes it difficult to determine whether or not the lesion actually is tuberculous. The French school does not agree with the German that in the majority of the cases uveitis is due to tuberculosis. Lagrange stated the belief that only a negative cutaneous reaction is of value. The authors believe that this subject deserves more accurate evaluation and that a more critical quantitative method of testing should be used. The merits of the Pirquet cutaneous inoculation and of the Mantoux intradermal injection of tuberculoprotein are discussed.

In the authors' investigations the intradermal test was used. Injections of 0.1 cc. of old tuberculin in dilutions of 0.001, 0.0001, 0.00001 and 0.000001 mg. per cubic centimeter were given intradermally. The

solutions were freshly prepared each time that they were used. All four injections were made at the same sitting. The cutaneous reaction was noted in twenty-four hours. A reaction was considered positive if the area of reaction to the two weakest dilutions was 4 mm., or 10 mm. in diameter to the two stronger dilutions. The reactions were graded as negative, weak, moderate or strong, the last constituting a definite reaction to the two weakest dilutions.

Of 55 cases of uveitis, a strong reaction was noticed in 62 per cent. Of the same group, the uveitis was believed to be due to other etiologic factors in 15 cases; in 47 per cent of which the Mantoux test was positive. Of 73 cases in which the condition was judged to be tuberculous from the clinical findings, the reaction was positive in 84 per cent.

The authors conclude with an interpretation of the positive and negative results.

P. R. McDonald.

Society Transactions

EDITED BY DR. W. L. BENEDICT

COLLEGE OF PHYSICIANS OF PHILADELPHIA, SECTION ON OPHTHALMOLOGY

Burton Chance, M.D., *Chairman*

George F. J. Kelly, M.D., *Clerk*

April 24, 1947

Rubeosis Iridis Diabetica: Report of a Case. DR. JOSEPH WALDMAN and (by invitation) DR. DAVID NAIDOFF.

Rubeosis iridis is a comparatively rare condition in which a non-inflammatory proliferation of new blood vessels occurs on the anterior surface of the iris and which is usually associated with glaucoma. Salus, who first described the condition in 1928, used the term rubeosis iridis diabetica when he observed it bilaterally in 3 cases of diabetes, in all of which glaucoma eventually developed.

The appearance of the iris is characteristic; the anterior surface is covered with radially arranged new vessels, especially near the sphincter region, where the individual vessels anastomose to give the appearance of a ring about the pupil. The vessels end at the pigmented margin, without extending over it. Beginning at this capillary net, larger vessels spread over the iris and disappear in the angle of the anterior chamber. In 1937 Kurz first described the gonioscopic and pathologic features. Gonioscopic study revealed large vessels running peripherally into the angle, where they divided into innumerable branches to connect directly with Schlemm's canal and to form extensive peripheral synechias. With the development of atrophy of the iris the vascular net in the rubeotic eye tended to disappear. Pathologic study revealed that the new vessels were unassociated with inflammation or with newly formed tissue but lay in and on the iris itself. Hemorrhagic retinopathy and a tendency to vascular proliferations in and on the retina and the optic nerve was a frequent concomitant change.

Hyphema was common, and in all reported cases a recalcitrant glaucoma resulted, which yielded only temporarily, or not at all, to treatment, either medical or surgical. In 1940 Fralick reviewed 32 reported cases of rubeosis iridis associated with diabetes and added 3 cases which he had observed; in only 1 of the 35 cases did glaucoma fail to develop, and in this case, reported by Wegner in 1939, treatment was considered successful when an intracapsular cataract extraction was performed. Since then, Meyer and Steinberg, Scobee, Grury and deRoeth have reported the use of cyclodiathermy in controlling the glaucoma in rubeosis iridis diabetica, although this treatment resulted in atrophic eyes.

An interesting observation is the relation of arterial hypertension to rubeosis; this was first mentioned by Kurz. Fralick, in his review, found hypertension in 16 of the 35 cases. It seems that diabetes and

hypertension together in the same patient are associated with a much higher percentage of vascular pathologic change than when either is present alone.

The following case is from the No. 2 ophthalmologic service of the Jefferson Medical College Hospital.

M. G., a woman aged 58, first learned in 1943 that she had diabetes. Subsequent treatment had been dietary and haphazard. Insulin had not been used. For the six months prior to admission she had also been treated for hypertension. In December 1946 she had suffered sudden loss of vision in her left eye, which was said to be due to a severe hemorrhage in the vitreous. On Feb. 24, 1947, one week before her admission to the hospital, the patient became aware of what she termed "pink vision" in her right (good) eye; everything at which she looked had a reddish hue. That night she had severe pain in the right eye, and the next morning vision was limited to light perception. That day she was seen by one of the members of the staff and a diagnosis of acute glaucoma was made. At this time hyphema was present. Treatment consisted of administration of physostigmine in drops and application of hot compresses, but the elevated intraocular tension, pain and loss of vision persisted until her admission to the hospital, on March 1.

On her admission, ophthalmologic examination revealed that vision was limited to light perception in the right eye and was 4/60 in the left eye. Intraocular pressure (Schiøtz) was 65 mm. in the right eye and 16 mm. in the left eye. The right eye was severely congested throughout. Biomicroscopic examination showed that the cornea was edematous; many small, gray, keratic precipitates were present. The aqueous was slightly turbid. The stroma of the iris was atrophied, and a narrow ectropion uvea extended around the entire inner border of the pupil. Just outside this pigmented margin of the pupil was a fine network of new-formed blood vessels, which covered the sphincter zone in a wreathlike fashion and gave a reddish hue to this portion of the iris. From this vascular zone on the surface of the iris several more or less straight, and larger, vessels coursed toward the base of the iris; some terminated in tufts of small capillary networks at about the base of the iris; others disappeared behind the limbus. Uveal pigment and grayish debris were noted on the anterior surface of the lens, which had undergone general loss of transparency with other cataractous changes. Examination of the fundus was impossible because of the changes in the media.

Externally, the left eye presented a normal appearance. The vitreous was loaded with fine and coarse opacities. Many infiltrates typical of diabetes were noted in and about the macular area, and numerous retinal hemorrhages, both punctate and flame shaped, were present throughout. The retinal arterioles showed advanced sclerosis. Biomicroscopic examination revealed numerous fine gray and brown keratic precipitates. The anterior chamber was clear. Atrophy of the iris stroma and absorption of iris pigment were evident. On the iris, near the pupillary border, at about 9 o'clock, a tiny network of new vessels was noted. The changes in the lens were similar to those seen in the right eye.

General physical examination showed a blood pressure of 210 systolic and 120 diastolic, generalized arteriosclerosis and slight cardiac enlargement.

The Kahn reaction of the blood was negative. The blood sugar measured 235 mg.; the blood urea nitrogen, 25 mg., and the serum cholesterol, 222 mg., per hundred cubic centimeters. Urea clearance was 35 per cent. Coagulation time was three and one-half minutes; bleeding time was one and one-quarter minutes; capillary fragility (tourniquet test) was normal. The urine showed 4 plus reaction for albumin, a trace of sugar and many red blood cells and epithelial casts.

The electrocardiogram showed slight left axis deviation; there were no other findings indicative of myocardial change.

The diagnosis was rubeosis iridis diabetica and secondary glaucoma in the right eye and diabetic retinopathy and retinal arteriosclerosis in the left eye; diabetes mellitus; arteriosclerotic and hypertensive renal disease, and generalized arteriosclerosis.

As miotics, physostigmine, neostigmine, and DFP (di-isopropyl-fluorophosphate) were all employed, without any decrease in the intraocular tension; on the contrary, these drugs increased the pain and caused incessant vomiting, which prevented proper control of the diabetes. Pilocarpine nitrate, 8 per cent, was then used, with similar results, even when the strength was reduced to 1 per cent. After three weeks, since no beneficial results were obtained, all miotics were discontinued, and the patient became fairly comfortable, although vision was completely lost. From the time of her admission the patient had received 20 mg. of rutin four times a day. On April 4, 1947, the patient again suddenly experienced excruciating pain in the right eye. Examination then revealed a severe hyphema with intraocular pressure of 68 mm. of mercury (Schiøtz). The pain has now diminished, but the hemorrhage in the anterior chamber is still present. The patient's family was informed that operative procedures were usually unsatisfactory in these cases and that enucleation was to be considered for the relief of intractable pain.

DISCUSSION

DR. BURTON CHANCE: I recall a case of rubeosis in the service of the late Dr. Schwenk, twenty or more years ago, in a diabetic woman, who failed to return for further study because, so we were informed, she died of her general disease. I have not seen another case since.

Contaminated Ophthalmic Ointments. DR. LOUIS LEHRFELD and DR. EDWARD J. DONNELLY.

This paper was published with the discussion in the July 1948 issue of the ARCHIVES, page 39.

Infections of the Vitreous and Streptomycin: Experimental Studies. DR. IRVING H. LEOPOLD and (by invitation) DR. RICHARD DENNIS and MARJORIE WILEY, B.A.

Streptomycin penetrates poorly from the blood stream into the vitreous humor of normal rabbit eyes. Local methods of administrating the drug were studied and compared for their abilities to produce adequate concentrations of streptomycin in the vitreous. Subconjunctival injections, injections into the anterior chamber, and retrobulbar injection of streptomycin with iontophoresis in the anterior

segment produced higher levels than those obtained with systemic administration. These methods were tried against the standard infections of the vitreous produced by colon bacteria. Direct intravitreal injection of streptomycin, retrobulbar injection with iontophoresis and injections into the anterior chamber reduced the severity of experimental infections of the vitreous due to colon bacteria. They were effective in the order listed. Direct intravitreal injections of streptomycin produced retinochoroidal exudation and subsequent degeneration. In concentrations below 800 micrograms per injection, the damage was minimal and was limited to the site of injection.

DR. RICHARD DENNIS: From the work that we have done, it seems that direct intravitreal injection is the most efficacious of the local methods of administering streptomycin. It also appears that the injection of reasonable quantities of streptomycin, at least up to 800 micrograms, can be made with no more damage than would follow a similar direct injection of saline solution. With improved methods in the refinement of production of the drug this relative safety will probably be more obvious. In the case of a severely infected eye, in which other remedies have proved to be of no avail, the ophthalmologist would seem justified in trying this method. For intravitreal injections the solution should be as near isotonic as possible. In the lower concentrations this isotonicity is best obtained by diluting the drug in isotonic sodium chloride solution U. S. P. In higher concentrations considerable osmotic effect occurs, and here it is best to dilute with distilled water.

DR. IRVING H. LEOPOLD: For the benefit of those who might try retrobulbar injections of streptomycin, it is necessary to point out that such injections may be painful. Intramuscular injections of streptomycin are painful to some persons. Procaine does not interfere with the action of streptomycin and could be used with, or prior to, retrobulbar injections of streptomycin.

Role of the Vertically Acting Muscles in Concomitant Strabismus. DR. EDMUND B. SPAETH.

A series of cases was presented to illustrate the role which the vertically acting muscles must play in the causation of convergent, as well as divergent, strabismus. The cases illustrated a relation of the conjugate muscles to muscle overaction in one eye and to muscle underaction in the other eye, a degree of vertical deviation being always present but changing with each possible position of the lateral rotations. Further, overaction was found to be fairly common in the homolateral antagonistic muscles with and without disturbances of the contralateral conjugate muscles. The various possible combinations were presented.

Disturbances in the vertically acting muscles modify to a high degree the corrective surgical measures necessary. Certain rules with respect to the sequence of the necessary operations (lateral and/or vertical) in the various situations seen were presented.

DISCUSSION

DR. GLEN G. GIBSON: Once again, we are indebted to Dr. Spaeth for calling out attention to an extremely important, and frequently neglected, phase of ophthalmology. The time has come when we can

no longer neglect the subject of the role of the vertically acting muscles in horizontal strabismus. This is an important paper, for two reasons: (1) It brings us intimately into contact with Dr. Spaeth's extensive surgical experience in these complex cases. (2) The literature in the past has been inadequate as a guide to the handling of such cases; yet it illustrates the fact that we as clinicians are in need of precise definitions by which we can understand each other more thoroughly when we use such terms as spasm, overaction, vertical component and vertical element.

This paper is too all inclusive and extensive for one to discuss all the aspects of it, and I feel that I may best serve our purpose by summarizing briefly what Dr. Spaeth has said. He has pointed out that there are cases of pure horizontal deviation without any vertical element. He has also pointed out that if one studies such cases carefully one can determine in many of them that there is vertical imbalance, either hypertropia or hyperphoria. The careful study of these cases is rewarded by a much better surgical result. There are two main groups in which combined vertical and horizontal tropias are encountered. The first type is primarily a concomitant strabismus with a secondary vertical deviation. The commonest of these is the type in which there is bilateral overaction of the inferior oblique muscle. The overaction of the inferior oblique is merely the secondary participation of these muscles in the esotropia. The second type is of primary paralytic origin and the vertical deviations are primary, the horizontal deviation being merely the secondary device that the patient uses to avoid the disturbing diplopia which results in cases of vertical deviation. The differential diagnosis of these two types is relatively easy when one considers that when the horizontal deviation is primary the excessive action of the inferior oblique muscle is bilateral. It is equal and symmetric. In other words, both inferior oblique muscles participate equally. It is just the reverse in the cases in which the vertical deviation is primarily paralytic in origin; then the deviation is always different in the two eyes. The deviations are not symmetric, and the difference between primary and secondary deviations can usually be measured.

There is a third type of mixed deviation in which the eyes have become so concomitant that it is impossible to tell precisely which muscle was primarily involved. Some ophthalmologists will not admit that in cases of deviations which were originally paralytic the eyes become progressively more concomitant as time passes, so that it is impossible to identify the original offending muscle; I feel, however, that such cases occur frequently.

Dr. Spaeth has called attention to the vital importance of sensory correspondence in these cases. I should like to cite 2 cases, both of men aged 22, which illustrate this all-important point. Both patients had 10 Δ of left hyperphoria when measured in the primary position. The first man presumably had had normal eyes and normal binocular vision up to the time of an automobile accident, at the age of 22, when a typical paresis of the left superior oblique developed. A complete myotomy was performed on the inferior oblique muscle of the offending eye, with the resultant reduction of hyperphoria to 0.5 Δ. This excellent result is due to the normal binocular sensory correspondence before the onset of the condition.

The other man had an entirely different history, and a much greater surgical correction was necessary. This condition was also a paresis of the superior oblique muscles, onset of which was at 2 years of age; the patient had very abnormal sensory correspondence and the surgeon could get little help from the binocular reflexes in maintaining alinement. Even the deviation was essentially difficult to determine, as was the diagnosis, in view of the extremely abnormal sensory correspondence. Myotomy of the inferior oblique muscle on the offending side was combined with a 3 mm. recession of the contralateral inferior rectus muscle. The residual hyperphoria was 3 △, even though the correction had been more extensive. It is important to know the status of the sensory mechanism before attempting surgical correction in cases of vertical deviation.

Dr. Spaeth has called attention to the importance of recognizing inhibitional palsy in cases of these deviations. I would refer you to an article by Dr. F. H. Adler (*Tr. Am. Ophth. Soc.* **81:** 255, 1945) which is clear on this subject. The problem has also been discussed, though less clearly, by Chavasse (Worth's Squint, Seventh Edition by F. Bernard Chavasse, Philadelphia, P. Blakiston's Son & Co., Inc., 1939). Dr. Spaeth has called attention to the fact that more than a cosmetic result is desired, and that the obtaining of binocular vision may be the ideal sought.

The most important factor in obtaining binocular vision in these cases is the age at which surgical treatment is instituted. It is not necessary to operate before the patient is 3 years of age, nor desirable to delay until the child is past 4 years old. In other words, the ideal time for surgical correction is between 3 and 4 years of age. If the child is treated at that age, he is still immature enough to acquire normal binocular vision. Dr. Spaeth has pointed out that with disturbances of the vertical muscles associated with horizontal deviation the results are frequently better than with the purely horizontal deviations; it has been my experience that the results of surgical correction of the vertical muscles, when the condition has been correctly diagnosed and proper treatment carried out, has been more satisfactory than the results which have been achieved in the uncomplicated cases of horizontal deviation.

DR. GEORGE F. J. KELLY: I should like to ask Dr. Spaeth what his experience has been in cases of torticollis due to paralysis of an oblique muscle. When does the torticollis disappear after correction of the defect of the oblique muscle?

I think Dr. Spaeth stated that when there are both a vertical and a lateral component he operates first on the muscle with greater paralysis. I also understood him to say that with correction of the horizontal component there is always improvement in the vertical component and that with correction of the vertical component there may be no alteration in the horizontal component. Would it not be worth while to operate on the horizontal component? One would surely get some correction of the vertical component, and perhaps one would not later have to do so much on this component.

DR. EDMUND B. SPAETH: Dr. Gibson brought out three points which are quite true. The first was stated by Dr. White on this floor

many years ago, "Seventy-five per cent of concomitant strabismus is accompanied by a vertical deviation"; too often, nothing is done about it.

Dr. Gibson spoke of "so many millimeters of recession or resection." Many things enter into the surgical correction of a vertical deviation. To correct such a deviation by millimeters is quite impossible. It is disheartening to see the poor results one obtains in any type of operation on an inferior oblique muscle when, instead of operating on an inferior oblique muscle, one should have made the opposite surgical correction, that is, resection or recession of the superior oblique muscle. It is only by comparison of the total amplitude of the action of the conjugate yoke muscle with that of the muscle involved that one can decide whether an inferior oblique or a superior oblique muscle should have been operated on.

As to torticollis, there is no question about this except concerning the time of its disappearance. If torticollis is not improved by monocular occlusion, prior to operation, it will take a long time to disappear.

As to the sequence of surgical procedures on the vertical and the lateral components, I have been distressed and embarrassed several times to find that subsequent correction of the vertical muscles has upset the previous surgical result on the lateral muscles. If the vertical component of the deviation is the greater, it is wise to take care of that before correction of the lateral deviation is even attempted, for one cannot tell for certain the effect on the lateral deviation.

NEW YORK ACADEMY OF MEDICINE, SECTION OF OPHTHALMOLOGY

W. Guernsey Frey, M.D., *Chairman*

Maynard C. Wheeler, M.D., *Secretary*

Oct. 20, 1947

INSTRUCTION HOUR

The Surgical Technic of and Indications and Contraindications for Keratoplasty. Dr. R. Townley Paton.

REPORT OF CASES

Scleromalacia Perforans. Dr. Melvin Harbater (by invitation).

The disease is probably a manifestation of the rheumatoid diathesis and is characterized by the appearance in the sclera, anterior to the equator, of small yellow excrescences, which break down, producing holes in the sclera and exposure of the underlying uvea. The early lesion is a small sterile abscess. With extension of necrosis and sequestration of scleral tissue, the characteristic hole is produced. The pathologic picture is essentially that of rheumatoid disease in any connective tissue. Visual disturbances and other symptoms are produced by complicating disease, especially uveitis.

A characteristic case was presented.

DISCUSSION

DR. EDWARD DOUGLAS (by invitation): I have seen 2 other cases of scleromalacia perforans; in both the condition was associated with rheumatoid arthritis, and the patients were characteristically malnourished and asthenic. That rheumatoid arthritis is of infectious origin and usually occurs at a much earlier age suggests the possibility that it is an earlier stage of the same pathologic process as scleromalacia. Could it be a degenerative process superimposed on the rheumatoid disease?

Zinc oxide (20 per cent) administered locally has been suggested in treatment of this condition. It is doubtful whether this medication will help to repair a hole. Vail has proposed scleral resection to repair the hole. The multiplicity of holes makes this of questionable value.

The pathologic process is slowly progressive and eventually leads to destruction of the eyeball. In the case presented it will be of interest to see whether the process will advance beyond the equator.

DR. MELVIN HARBATER: I believe that zinc oxide was used in 1 of the doubtful cases of scleromalacia. I doubt whether it has any effect on the disease.

PAPERS OF THE EVENING

Changes in the Fundus in Young Veterans. DR. SANFORD R. BLOOMENTHAL (by invitation).

Four cases of lesions of the fundus in young veterans representing chorioretinitis of probable tuberculous origin; atrophy of the optic nerve without changes in the field; retinal hemorrhages accompanying purulent dermatitis; retinitis proliferans with detached retina, respectively, were presented.

DISCUSSION

DR. BRITTAIN F. PAYNE: One is at a loss to know the cause of many such lesions of the fundus. The effect of Army rations, or lack of rations, of exposure to heat and cold and of various diseases and injuries is portrayed in the cases just presented. "Trench foot" and cardiovascular and nephritic disease were common in these patients.

I have a few lesions to add to Dr. Bloomenthal's list: hole in the macular region, block of the inferior temporal artery and retained foreign body.

Postvaccinial Ocular Syndrome. DR. EMANUEL ROSEN, Newark, N. J. (by invitation).

Two types of ocular complications follow vaccination: (*a*) pustule formation, following accidental inoculation, and (*b*) ocular complications following or associated with the systemic response to vaccination. Of the first variety several hundred cases have been reported; of the second there are only a dozen recorded in the world's literature. An attempt was made to show that the pathologic process in postvaccinial encephalitis and the process in the other virus exanthems are identical and that the ocular syndrome is of necessity related to, and a part of, the encephalitic picture.

Several cases of ocular complications were described, including interstitial and dendritic keratitis, choroiditis, iritis, thrombophlebitis, central serous retinopathy, thrombosis of the central retinal vein, thrombosis of the central retinal artery and panophthalmitis. These complications all occurred ten to twenty days after vaccination.

Mild Glaucoma. Dr. Adolph Posner and Dr. Abraham Schlossman (by invitation).

In 40 of a series of 373 cases of primary glaucoma the disease remained unusually mild throughout the entire course. Several of the patients were observed for many years. In some cases the condition was discovered accidentally during routine examination; in others the diagnosis was made because of the presence of glaucoma in other members of the family, while in still others mild symptoms of glaucoma were complained of. In such cases the ocular hypertension is not very high and is generally well tolerated. A good response to miotic therapy is the rule. The visual fields show no deterioration during the entire period of observation, and the fundi and visual acuity remain normal. Cases in which the elevation of tension was the only sign of glaucoma were included if a provocative test or a pupillographic examination or both gave a positive result. Three case histories were presented.

DISCUSSION

Dr. Otto Loewenstein (by invitation): There are two points I wish to stress: (1) pupillography as applied to glaucoma and (2) the question of heredity.

Pupillography had proved to give clinical access to the autonomic centers, and therefore I was very much interested in doing work on glaucoma, for the development of which central nervous factors were frequently considered, but had never been shown, to be responsible. I made examinations in cases of both early and more advanced glaucoma and found that symptoms of central autonomic origin existed to an equal degree in the two types. Sometimes, they were even more pronounced in early than in advanced cases. The pupillographic pictures showed certain characteristics of the central autonomic nervous system which were different from those of other well known types of central lesions. They were always present on both sides, even in cases in which clinically the condition was unilateral. These facts, in connection with the peculiarities of the pupillographic findings, pointed to the posterior part of the hypothalamus as a possible site of the lesion.

The number of patients, about 70, examined pupillographically is too small for general conclusions. At this stage of development of the problem the contributions which I am able to make to the clinical diagnosis of glaucoma in initial and doubtful cases may be cautiously defined as follows: There is a connection, causal or not, between hypothalamic lesions and simple glaucoma. When in a clinically doubtful case the characteristic pupillographic symptoms cannot be detected, the condition is likely to differ from glaucoma. Where they are detectable, glaucoma is possible, though not proved.

This brings me to the second point, that of heredity. In the small space of the hypothalamus, a great number of vegetative centers have

been localized which under pathologic conditions may produce very different syndromes, such as hypertensive vascular disease, diabetes insipidus, diabetes mellitus, exophthalmos and, briefly, all those conditions dependent on the hypophysiodiencephalic system. Either they, or glaucoma, or even both, independently or jointly, may appear as neighborhood symptoms. It would be difficult to understand that the hereditary disposition to disease processes within this small area would be a selective one in the extreme sense that it might be concerned with individual nuclei, and not with the area as a whole. This is the theoretic reason that I feel that studies in the genetics of glaucoma should include all possible disorders of the interbrain, and it is for this reason that I agree completely with the approach to the problems of glaucoma shown so ably by the speakers.

Let me finish by emphasizing that all this work is still in its beginning; but it is a promising beginning.

DR. SYLVAN BLOOMFIELD (by invitation): It may be of interest to mention a case in the glaucoma clinic at the New York Eye and Ear Infirmary. It emphasizes the point these authors have made concerning the unpredictability of the course that mild chronic simple glaucoma may take.

A white woman aged 48 had been followed in the clinic since 1931. At that time a diagnosis of bilateral chronic simple glaucoma was made and amply confirmed by the subsequent course. Between 1931 and 1942 she presented a tension of 35 mm. in both eyes on numerous occasions, and at one time a tension of 45 mm. was noted, in spite of the regular use of pilocarpine. For a brief period physostigmine was employed to keep the tension within normal limits. Because of elevated intraocular pressure, in spite of miotic therapy on two occasions, surgical intervention was advised but was refused. At no time was evidence of intraocular inflammation or acute congestion noted.

In 1942, because of persistently normal tension, use of miotics was discontinued, and no medication has since been employed. She has been seen regularly in the clinic, and at no time in these past five years has she shown a tension of over 26 mm. Vision in each eye is correctible to 20/25, and her fields are normal except for slight enlargement of both blindspots, a sign not particularly characteristic of glaucoma. She has been asked to enter the hospital for further study but has refused. A lability test made recently showed a result for both eyes that was within the upper range of normal. Clinically this patient has presented no evidence of glaucoma for five years. However, there seems no doubt of the diagnosis, and I present her case as an example of an unusually prolonged and fairly complete remission.

DR. ABRAHAM SCHLOSSMAN: Dr. Bloomfield's case is enlightening. I saw the patient with him this afternoon. If the tension is found to be elevated, no other signs of glaucoma are present and the fields are normal, one can delay treatment. The physician should keep the patient under observation for a few months before beginning treatment with pilocarpine and make certain of the diagnosis before starting the use of miotics. Many patients associate glaucoma with blindness, and it is important for the ophthalmologist to treat the patient psychologically. A note of optimism expressed by the physician may in itself contribute to keeping the disease in check.

A Procedure to Make the Elliott Trephine Operation Less Difficult.
DR. RAYMOND E. MEEK.

A simple method of performing the Elliot corneoscleral trephination was presented. Benedict's method of making the conjunctival flap so as to include Tenon's capsule was used. With a Wheeler or a Lunsgaard knife, an incision is made at the corneoscleral junction through one-half the thickness of the margin. The knife blade must be held perpendicular to the eye. The cornea is now easily split to a distance of 1 mm. With the trephine placed astride the corneoscleral margin and with the lower raised portion with its attached conjunctiva used as a stop or shelf, the opening is made. The trephine should be held perpendicular in order to get a cleancut disk or plug. The tissue of the iris, which now presents, is grasped near its base with iris forceps. With slight tension pulling the iris toward the pupil, the tissue is excised. If no prolapse of the iris occurs, it may be withdrawn by suction. The conjunctiva–Tenon capsule flap is replaced and sutured. Gentle massage is begun on the third day and kept up daily until the wound is healed and the circulation of aqueous established. A dressing is kept on the eye for a week.

DISCUSSION

DR. WILLIS S. KNIGHTON: I am in general accord with Dr. Meek's presentation of the operative procedure, but a few points merit discussion.

First, I do not agree with the practice of doing a paracentesis in the morning to lower the tension for an operation in the afternoon. It has been my experience that such paracentesis wounds have to be reopened two or three times a day in order to keep the tension down. If a paracentesis were done in the morning on an eye with a tension of 40 mm., I should expect to find the tension up to 50 mm. or more within a few hours, as the result of the secondary aqueous. It is better to reduce the initial tension by means of retrobulbar injection or by intravenous injection of dextrose solution. If these measures fail, one can then resort to posterior sclerotomy.

The question of late infection following trephination has little to do with the technic of the operation itself. One might almost say that the infection is a matter of luck; if the patient has a clean conjunctival sac, the eye will not become infected, but in the presence of conjunctivitis his eye is more liable to infection because of the thin bleb.

The preparation of the conjunctival flap is important; like Dr. Meek, I have had best results by following Benedict's technic. It is also well to dissect as little as possible in a horizontal direction in order to preserve untraumatized tissue at the sides of the trephine opening.

The technic of splitting the cornea is one that must be learned by experience. Many operators start this procedure with a sharp instrument and then change to a blunt dissector. Others feel that any blunt dissection is uncertain, or even dangerous, and prefer to complete splitting the cornea with a sharp instrument. My own preference is for the sharp dissection because I feel greater security in doing it that way. I do not know whether Dr. Meek's suggestion of first splitting the tissue vertically would simplify matters or not; perhaps he found it easier only because he has had considerable experience in the operation.

The necessity of splitting the cornea is evident when one refers to the measurements within the eye. According to Salzmann and others, the limbus is a zone about 1 mm. wide just peripheral to the end of Bowman's membrane. In practice, however, one looks for "clear cornea" as the dividing line when splitting the cornea. Dr. Johnson has made the interesting observation that the appearance of clear cornea cannot exist beyond Descemet's membrane; even though the outer layers of the cornea are clear, the inner layer cannot be transparent beyond Descemet's membrane because of the trabeculum. It will be seen from measurements that a trephine of 1.5 mm. or larger must go into clear cornea, that is, anterior to the end of Descemet's membrane, at least 0.5 to 0.75 mm. in order to avoid the ciliary body itself.

Ciliary processes should always be avoided if possible, but they are not detrimental unless they block the opening mechanically. It is not uncommon to find one or more processes in a well functioning trephine opening.

I do not believe that the practice of tilting the trephine to obtain a small hinge is very important. However, it is important to remember that the trephine blade may not be equally sharp around the whole circumference and that it is better to turn the trephine continuously in one direction than to rotate it back and forth. The continuous rotation insures a uniform cut.

Dr. Meek's suggestion of removing iris from the wound by suction is an interesting one. I have never tried it, but it sounds safer than fishing with forceps.

In the presence of definite uveitis, I should prefer to postpone a trephination until the eye became quiet. If the tension remained high during treatment of the uveitis, I should do repeated paracenteses.

Massage is very important. Since hearing Dr. Chandler's paper at a meeting at this Academy, I have followed his practice of applying continuous firm pressure, rather than alternate pushing with the fingers of the two hands. I believe that massage is contraindicated when there is no anterior chamber; the anterior chamber must be at least partially reformed before it is begun.

Dr. Raymond E. Meek: There is little on which I can take issue with Dr. Knighton. I think it is good practice to use retrobulbar injection and intravenous injections of dextrose, but I still feel that paracentesis helps in many cases of increased tension.

Book Reviews

The Physiology of the Eye. By Hugh Davson. Price, $7.50. Pp. 451, with 301 illustrations. Philadelphia: The Blakiston Company, Division of Doubleday Company, Inc., 1949.

This concise, well written book is timely. There have been many new developments in the field of ocular physiology in recent years, and a survey of the field has been a difficult task, since this necessitated the reading of many scattered articles. This book presents an up-to-date, short, but in many places critical, summary of the biochemistry, physiology and optics of the eye. It is comprehensive and includes five sections: intraocular dynamics and the transparent tissues; the mechanism of vision; the muscular mechanisms; visual perception, and optics.

The author's style is lucid, somewhat discursive but yet compact. The exposition generally is simple and adequate. The book is intended primarily for students of ophthalmology and should be a distinct aid to the candidate qualifying for the examinations of the American Board of Ophthalmology. But it should be considered only as an introduction to the subject, and as a foundation for more thorough study of original articles. It should afford the practicing ophthalmologist a comprehensive review of the fundamentals of ocular physiology and refresh his memory on many aspects of basic physiologic optics that he may have forgotten.

The illustrations, most of which are diagrammatic, are simple and clear and serve their purpose well. The list of key references provided is a valuable representation of outstanding, pertinent original contributions. The alphabetical index is adequate.

HUGO L. BAIR.

Current Therapy—1949. Howard F. Conn, M.D., Editor. Price, $10. Philadelphia: W. B. Saunders Company, 1949.

This book attempts to present the latest methods of treatment of a particular general medical condition as endorsed and currently used by competent medical authorities. It is not a review of the literature or an attempt to compile the numerous methods of treatment suggested for any one disease. Twelve consulting editors have selected a list of 200 leading American physicians who have contributed to the volume. It should prove a very useful book to the ophthalmologist who wishes to find out with the least expenditure of energy at least one method of treatment which is advocated by an expert in that particular field. The treatment of brucellosis, for example, is written by the chief editor. This article would be useful in the management of chronic cases of brucellosis with positive ocular involvement. The treatment of congenital syphilis is handled by 3 contributors, each one giving his individual method in conditions such as interstitial keratitis. It is a thoroughly practical book and is highly recommended for its concise and specific directions.

FRANCIS H. ADLER.

Manual de oftalmología clinica y teorica. By Prof. Manuel Marquez. Price, $9.00. Pp. 272. México, D. F., Mexico: Cuadernos Oftalmologicos, 1949.

This is the first of four projected handbooks on clinical and theoretic ophthalmology, designed to cover all phases of the subject. This volume covers the essentials of general clinical ophthalmology, especially with reference to examination procedures and the correction of refractive errors. It is in a sense a condensed revision, with inclusion of the latest advances in the specialty of the author's previous work, now out of print, "Lectures on Clinical Ophthalmology." The forthcoming volumes will take up in greater detail many of the topics only briefly discussed here, as well as subjects of a more advanced character.

Chapter 1 opens with a brief history of ophthalmology, illustrated with photographs of the most eminent past masters of the specialty, and then goes on to a general consideration of the anatomy, embryology, physiology and pathology of the visual apparatus. This is presented in large, bold strokes, so to speak, and conveys in the short space of 22 pages a splendid over-all picture of the characteristics of the visual organ in health and in disease. Chapter 2 considers errors of refraction and accommodation. It covers the essentials of general optics as a preliminary to the study of the dioptric system of the eye; then follows a clear, succinct description of the various objective and subjective methods of measuring and correcting refractive and accommodative errors. This chapter is the longest one in the book and includes brief, pertinent references, for example, to corrected curve lenses, bifocal lenses, iseikonic lenses and contact lenses. It touches also on muscular imbalances as they affect and are affected by refractive errors, the interplay of accommodation and convergence, the effect of some systemic diseases, such as diabetes, and of more localized diseases, such as glaucoma.

The remaining ten chapters cover the methods of general examination of the patient and specialized examination of the various parts, external and internal, including ophthalmoloscopy, visual field tests, tonometry, slit lamp examination and fundus photography, with a description of the fundus camera of Dr. Rivas Cherif. This apparatus, hardly known in this country, takes excellent fundus pictures, as shown by several plates.

After an over-all study of general and special symptomatology, the author presents an excellent discussion of the general principles of treatment, local and systemic, by means of drugs, dietary regulation and physical agents, such as heat, electricity and diathermy. The application to the eye and to various structures affecting the eye, such as hypophysial tumors, of the radiations from the visible and the invisible portions of the spectrum is treated with some detail. A brief discussion of ophthalmic operations in general and the instruments necessary for such operations is included. The last chapter discusses the social and professional relation of the ophthalmologist to his patients, his colleagues, the pharmacist and the optician (optometrist). The author's expressed opinion is that refraction is part of a medical specialty and should be limited to the ophthalmologist.

The book is designed primarily for persons who have but little knowledge of ophthalmology, and it aims to give them a good over-all, working knowledge of the subject. It is definitely didactic: "Do this, and do it thus and so." In this way, it manages to include an excep-

tionally large amount of material in a scant 270 pages. The style is remarkably lucid, and the clarity of thought, simplicity and economy of expression are dominant characteristics. In examination procedures, as well as in methods of treatment and operation, the author's well known penchant for simplicity in everything, and for a minimum of instrumentation and intervention, is everywhere evident. The book is profusely illustrated with diagrams and photographs, both plain and colored.

Those having a reading knowledge of Spanish will derive profit and pleasure from a perusal of this work. Younger ophthalmologists especially will find the book of value, but seasoned practitioners will also find a number of topics treated in a new and stimulating manner.

JOSEPH I. PASCAL.

The Practice of Refraction. By Sir Stewart Duke-Elder. Fifth edition. Price not stated. Pp. 309, with 216 illustrations. St. Louis: C. V. Mosby Company, 1949.

This well known little book is now in its fifth edition. The fourth edition came out in 1943 and was reprinted three times, a fact which attests to its popularity. The character of the book has not been changed, but the material has been brought up to date. Recent views on the biologic determination of refractive errors has induced the author to regard the significance of myopia from a different point of view. The book covers all phases of refraction, from physiologic optics to the manufacture of glasses.

FRANCIS H. ADLER.

Vision and the Eye. By M. H. Pirenne. Price not stated. Pp. 182, with 9 illustrations and 4 plates. London: The Pilot Press, 1948.

This is an excellent introduction to the study of the physiology of vision. The author himself has made many valuable contributions to the physiology of the retina and has the ability to present the subject to the uninitiated so that it is understandable—a not too common quality among those who deal in pure science.

The first three chapters are largely anatomic and deal with the gross anatomy of the eye and the microscopic anatomy of the retina. The next two chapters describe some of the properties of the rods and cones and discuss spectral sensitivity curves. Chapters 5 to 8 deal with the nervous activity produced in the eye by the action of light and the minimum amount of light energy necessary for vision. It is shown that if one considers quantum fluctuations, the threshold corresponds very closely to the minimum amount of energy which can be presented to the eye, i. e., 1 or 2 quanta. Chapter 9 is an interesting and brief sketch of the eyes and vision of insects. Chapters 10 and 11 deal with the visual acuity of man and its variation with changes in light intensity. There are four chapters on color vision and its anomalies and a short chapter on binocular vision.

The book is well written and should be read by everyone interested in ophthalmology. With short, easily readable books like this, there can be no excuse for the persistence of total ignorance of the physiology of the retina which seems to be widespread, even in the best circles.

FRANCIS H. ADLER.

Transactions of the American Ophthalmological Society. Volume 46. Pp. 673. Philadelphia, American Ophthalmological Society, 1948.

This is probably the largest *Transactions* ever issued by the American Ophthalmological Society. A list of the papers presented follows:

Cataract and Tetany Produced by Parathyroid Deficiency During Pregnancy, Lactation and Menstruation, Dr. Donald J. Lyle

Scleral Staphyloma and Retinal Detachment, Dr. Derrick Vail

Herniation of the Anterior Hyaloid Membrane Following Uncomplicated Intracapsular Cataract Extraction, Dr. Algernon B. Reese

Effect of Dicumarol® on the Visual Fields in Glaucoma: A Preliminary Report, Dr. William P. McGuire

Keratoplasty for the Treatment of Keratoconus, Dr. Ramon Castroviejo

A Surgical Anatomy of the Superior Oblique Muscle, Dr. Walter H. Fink

A Simple Appositional Suture in Operations for Cataract, Dr. Charles A. Perera

Therapy of Ocular Inflammations Based on Immunologic Principles, Dr. F. Herbert Haessler and (by invitation) Dr. Herman A. Heise

Primary Malignant Melanoma of the Optic Disk: Report of a Case, Dr. Frederick C. Cordes and (by invitation) Dr. Michael J. Hogan

Dermoids and Epidermoids of the Orbit, Dr. Raymond L. Pfeiffer and (by invitation) Dr. Russell J. Nicholl

The Dupuy-Dutemps Dacryocystorhinostomy, Dr. Alton V. Hallum

Secondary Subjective Effects Produced by Prisms, Dr. Walter B. Lancaster

"Myopia Cures," Dr. S. Judd Beach

Mechanics of Intracapsular Cataract Extraction, Dr. David O. Harrington

Retinoblastoma in the Adult, Dr. Ralph O. Rychener

Familial Central and Peripapillary Choroidal Sclerosis Associated with Familial Pseudoxanthoma Elasticum, Dr. Banks Anderson

Surgical Procedures in Retinal Vascular Disease, Dr. Angus L. MacLean

Epidemiology of Epidemic Keratoconjunctivitis, Dr. Phillips Thygeson

Ocular Lymphomas, Dr. Parker Heath

Perineuritis Optica, Dr. Arthur J. Bedell

Aerobic Glycolysis of Corneal Tissue, Dr. P. J. Leinfelder

Study of the Effect of Retrobulbar Anesthesia on the Intraocular Tension and Vitreous Pressure, Dr. Harold Gifford Jr.

Choice of a Miotic Agent Following Retrobulbar Anesthesia, Dr. Harold G. Scheie and (by invitation) Dr. Gaylord Ojers

A New Instrument—The Harrington Tonometer, Dr. David O. Harrington

In addition to the papers presented, the following theses are contained in this issue of the *Transactions:*

Vascularization of the Cornea: Its Experimental Induction by Small Lesions and a New Theory of Its Pathogenesis, Dr. David G. Cogan

Enucleation and Allied Procedures: A Review, and Description of a New Operation, Dr. Jack S. Guyton

Amblyopia ex Anopsia: Observations on Retinal Inhibition, Scotoma, Projection, Light Difference Discrimination and Visual Acuity, Dr. S. Rodman Irvine

Evaluation of Night Vision, Dr. Phillip Robb McDonald

Surgical Treatment of Recurrent Pterygia, Dr. John S. McGavic

Direct Surgery of Underacting Oblique Muscles, Dr. John M. McLean

Ocular Effects of the Choline Esters, Dr. Kenneth C. Swan

The editor of the *Transactions,* Dr. Wilfred Fry, is to be congratulated on having produced a magnificent volume, which must represent an enormous amount of work. FRANCIS H. ADLER.

Medicine Throughout Antiquity. By Benjamin Lee Gordon, M.D. Price, $6. Pp. 818, with 157 illustrations. Philadelphia: F. A. Davis Company, 1949.

The author of this book is well known in ophthalmologic circles for his numerous articles on ophthalmologic history. This book endeavors to collect the methods by which medicine was practiced in antiquity. Part I, comprising 429 pages, deals with medicine before the era of the Greeks, and Part II, with Greek, Alexandrian and Roman medicine, together with a chapter on Talmudic medicine. It represents an enormous amount of work and, in addition to being interesting reading, should prove a valuable reference book. FRANCES H. ADLER, M.D.

Outwitting Your Years. By Clarence William Lieb, M.D. Second printing. Price, $2.75. Pp. 278; no illustrations. New York: Prentice-Hall, Inc., 1949.

This is a book for the lay public on how to grow old and like it. It is not a medical book on geriatrics and contains a short two pages on the ocular diseases of old age. The book is full of amusing anecdotes and will probably be useful to the patient who is resentful of the infirmities of old age. FRANCIS H. ADLER, M.D.

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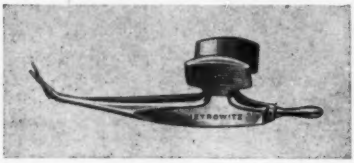

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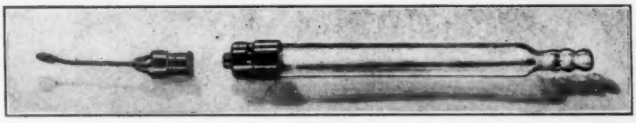

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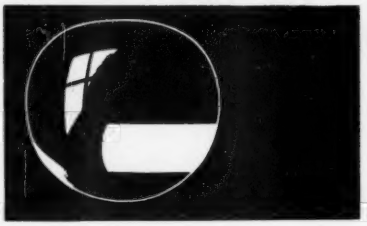

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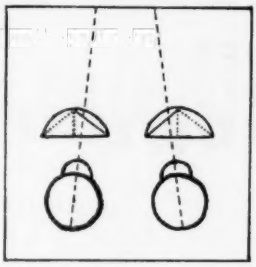

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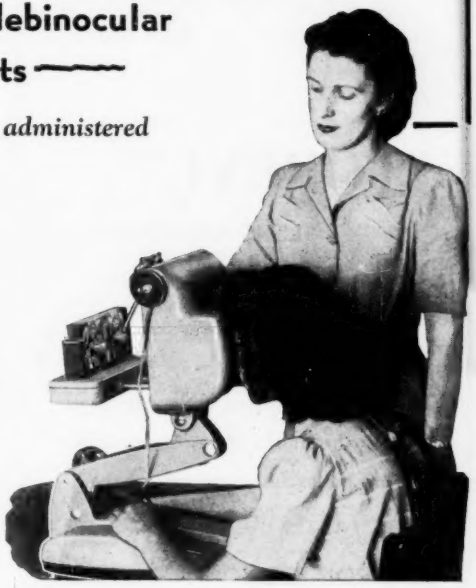

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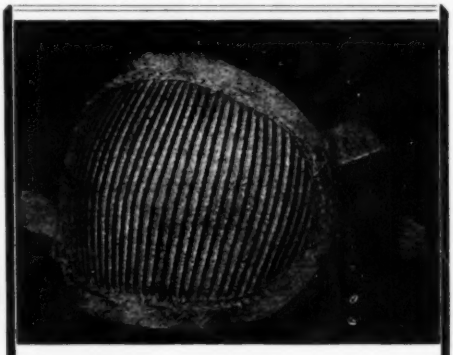

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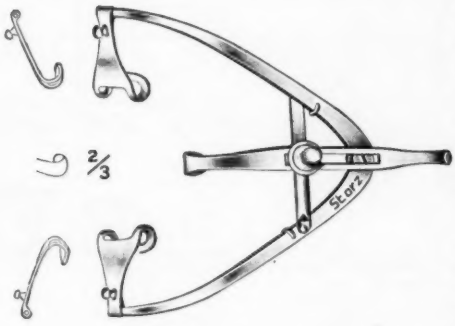

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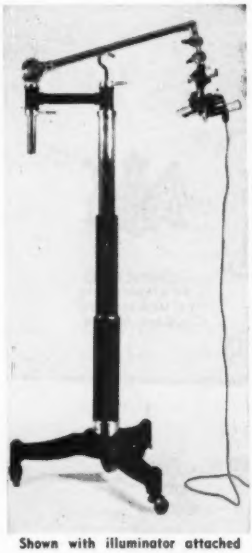

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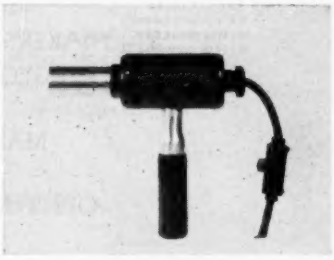

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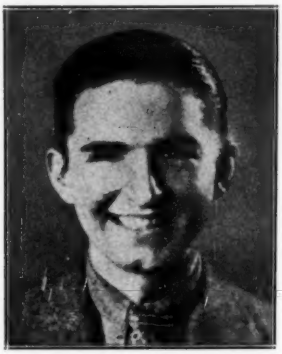

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